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THUNDER AND LIGHTNING.

Franklin's Experiment.

THUNDER AND LIGHTNING.

BY

W. DE FONVIELLE.

TRANSLATED FROM THE FRENCH, AND EDITED BY

T. L. PHIPSON, PH.D. F.C.S. &c.

Illustrated with Thirty-nine Engravings on Wood.

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TRANSLATOR'S PREFACE.

In accepting the task of translating the following pages, I have been dealing with a subject of very great interest. The electric phenomena of our atmosphere are indeed well calculated to impress the minds, not only of those who for many long years have been accustomed to deal methodically with Nature's most energetic forces, but also of those who, whilst contemplating her works with profound admiration, long to have the various and wonderful phenomena systematically grouped and explained in a popular manner, according to the latest results of scientific research.

M. de Fonvielle's writings have attracted much notice in France, owing to the happy manner in which he calls his readers' attention to certain facts hitherto treated of in abstruse scientific works only, and to others again, often observed and spoken of, over which he appears to throw quite a new light.

Although we have done our utmost to adhere strictly to the text of our Author, it has been quite impossible, in transcribing this little work into a more Northern idiom, to do complete justice either to his wit, his fine poetic feeling, or to his deep admiration for the works of the Creator. He may feel inclined to repeat to us the Neapolitan reproach :

"Voi fate le cose ad occhi chiusi ;"

but then the poetical brilliancy of the lightning-flash, in his hands, is such as to cause a Northerner to close his eyes !

And though there may be here and there throughout this volume glimpses of theory which we ourselves do not endorse in the present state of science, we have not thought this a proper place to enter into abstruse discussions of phenomena with which science has scarcely yet had time to deal.

In fact, it is when treating of lightning and its surprising effects that we become aware how little is really known of electricity. In spite of the numerous discoveries which have come to light of late years, and the various practical uses to which it has been applied, we still perceive, especially in a popular work of this kind, how many magnificent phenomena only await our

persevering inquiry to reveal new and wonderful things to us !

After all, the chief thing to be done is to accumulate facts. This was the principle which guided François Arago, when he wrote his excellent little *Notice sur le Tonnerre* in 1838. In the present volume M. de Fonvielle has been at great pains to collect together a considerable number of interesting observations, some of which are entirely his own, and many of the phenomena which he describes in so popular a manner will, doubtless, attract the attention of some of our learned meteorologists.

In collecting facts which we have not observed ourselves, the greatest care should be taken to bring forward with the observation proofs of its perfect authenticity. Sometimes, however, this is not possible, and an author is obliged to rely upon statements preserved in ancient or modern documents to which he has access. Some of the learned French ecclesiastics—a class of men who have always had much time on their hands—appear to have special reasons for exaggerating and rendering as marvellous as possible any natural phenomenon which they undertake to describe. It seems as if they wished to silence and confound the scientific observer *and his theories by* publishing these fantastic accounts, *most of which* are as impossible as they are untrue.

We are glad to find that M. de Fonvielle has avoided, as much as possible, this spurious source of information, and, when he happens to touch upon it, that, he treats it with the satirical contempt which it deserves.

The different kinds of lightning are scientifically discussed as to their probable causes, in an interesting little pamphlet by the Vicomte du Moncel, entitled *Notice historique et théorique sur le Tonnerre et les Eclairs* (Paris: Hachette, 1857). Besides the three distinct forms recognised by Arago—viz. ordinary zigzag or forked lightning (which is sometimes much branched), sheet-lightning and globular lightning—another description has of late years been several times observed. It was noticed in Paris by one of my brothers in 1858, when lightning struck a tree about half a mile from our house, on the Boulevard du Mont Parnasse. It appeared as a vivid streak of flame followed by an infinite number of sparks, and the phenomenon might have been attributed to the fall of an aërolite. However, M. du Moncel brings forward two similar observations which leave no doubt in my mind that this particular form of lightning is not uncommon when the electric discharge strikes objects on the surface of the earth.

The various colours which lightning affects appear to depend not only upon the degree of rarefaction of the

atmosphere where the discharge occurs, but also upon the force of the discharge.

The term sheet-lightning has been applied indiscriminately by some writers to the reflections of a storm below our horizon, and to those immensely wide flashes which occur sometimes in clouds far above the horizon, and are not followed by thunder. This is sheet-lightning properly so called. M. de Fonvielle attributes it to the extreme rarefaction of the higher atmosphere, and his explanation will probably apply to many cases. In my paper, *Sur quelques Phenomenes météorologiques observés sur le Littoral de la Flandre* (*Comptes-rendus de l'Acad. des Sciences*, Paris, 1857), I showed that sheet-lightning occurred sometimes between two clouds in close proximity, which, when the wind arose and separated them, afterwards produced ordinary forked lightning followed by thunder. In the first case the layer of air traversed by the electric spark is not great enough to produce the vibration called thunder; moreover, the light of the flash is reflected over a very large extent of cloud.

The phenomenon of globular lightning is only witnessed during intense electric disturbance of the atmosphere; it appears to be a small globe of air or vapour in a highly electrical state and intensely luminous; it discharges its electricity on approaching any object

which is oppositely electrified, or becomes so in its presence.

Cases in which lightning has been observed to rise from the earth or from the sea are, perhaps, not so far as some suppose. Admiral Fitz Roy mentions two cases in his *Weather Book*. as witnessed by himself.

M. de Fonvielle has culled his observations from the most ancient writings as well as from modern observation, so that he has given us at once a picture of the past and present of thunder and lightning. What may we not expect for its future? We feel convinced that his little volume will prove well calculated to insure popular interest, and to call the attention of persons unaccustomed to observe to some of the wonderful phenomena which surround us in this world.

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THUNDER AND LIGHTNING.

I.

A STORM ON THE PYRAMIDS.

We will not do the Hyperboreans the honour of attributing to them the invention of lightning-conductors, though Herodotus tells us that these people were accustomed to shoot arrows towards the clouds for the purpose of withdrawing their electricity. Heaven forbid also that we should seek to deprive Franklin of the finest portion of his scientific renown, to honour with it the memory of the Ædui and the Tolosites, because the *Commentaries* of Cæsar appear to prove that these Gallic tribes lighted great fires to preserve themselves from storms.

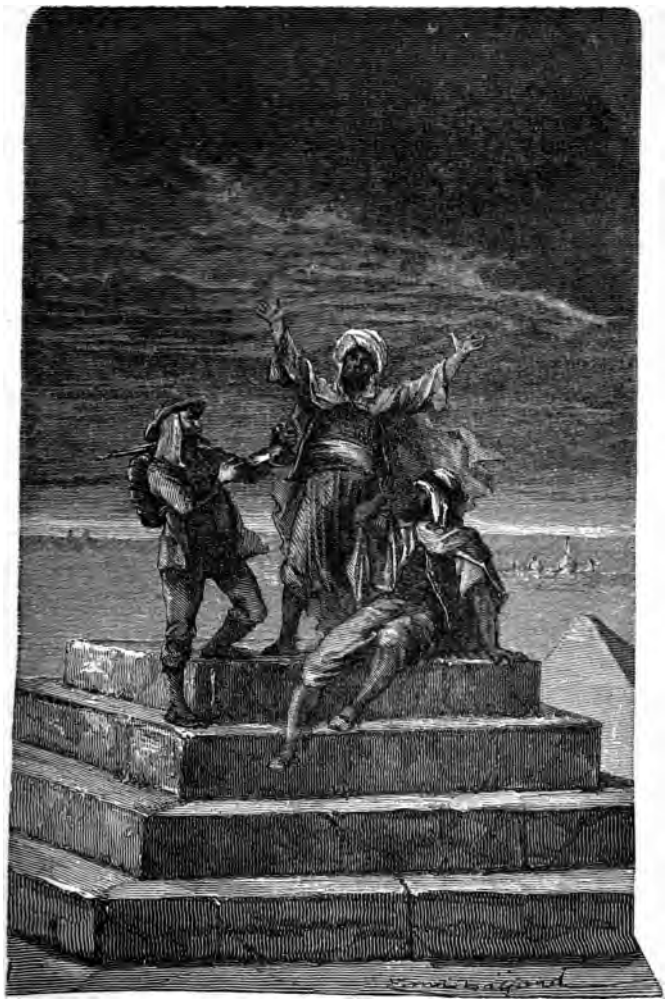
We will not imitate either the Abbé Gineau, who declared before the *Association pour le Progrès des Sciences* that, twenty centuries before Rommas, the Romans were acquainted with the use of the electric kite. Like himself, however, we know the medallion engraved by Pellarin, on which we see a somewhat fantastic figure guiding towards the sky an apparatus armed with an iron point.

Certainly *it would be highly* imprudent to believe that *the discoveries of the* author of "Poor Richard" had

not been anticipated by similar inventions familiar to the great nations of Antiquity, the recollection of which has perished like that of so many other secrets, lost in the long and sad intellectual darkness of the Middle Ages.

A few years ago Herr Werner Siemens was surprised by a storm whilst upon the highest platform of the pyramid of Giseh. The learned German perceived that a flow of electric matter escaped from his finger whenever he extended it towards the heavens. The marvellous current which then manifested itself was powerful enough to give rise to a remarkable hissing noise, which caused his Arab guides no little astonishment. Soon, the celebrated physicist, taking hold of a gourd which had a metallic button, amused himself by drawing a few sparks from it. This spectacle was more than the poor Mussulmans, who accompanied him, could bear. How could they remain in the service of an enchanter, who possessed the means of playing with thunder, and who drew lightning from his pocket as a toy? In spite of everything that Herr Siemens could say to retain them, the unfortunate Bedouins took to their heels, and descended with dangerous rapidity the steps that they had had so much difficulty in mounting. In a very short time they disappeared in the desert, without having dreamt of claiming their salary, so great was the fright that possessed them!

The Pyramids date before the period at which the tombs were excavated in the rock. And since the time when the mummies, which are now actually falling to dust there, were nourished at the breast of their mothers, a hundred generations of the faithful have knelt in the temples where shone the empire of Memphis. A hundred others have listened to the teachings of the pontiffs of Thebes Hecatompylos. Can we suppose that, during these immense periods of time, the priests of Isis had not once observed what the learned Prussian saw? Can



A Storm on the Pyramids.

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we believe that these men, so learned, such profound interpreters of natural phenomena, had never once recognised the electric influence of points?

The learned have discovered, without much effort of imagination, that the word pyramid itself comes from the Greek root *pyr*, which means fire. But are they right to add, that this term was chosen simply to indicate that these monuments terminated in a point? Is it not more logical to suppose, that some illustrious predecessors of the learned American had seen these mountains of stone crowned with flame, illuminated by the unknown energies of the earth. The colleagues of Manetho and the masters of Moses doubtless did not restrict themselves to teaching that immense columns of stone can produce the same effects as our rods of iron. We should say, on seeing the manner in which they have multiplied the obelisks around their temples, they were aware that these immense needles possess the property of withdrawing the electric fluid from the clouds. Certainly, they would not have committed an error once made by a perpetual secretary of the British Academy of Sciences, who proposed, in a work which has nevertheless become immortal, to crown the obelisk of Luxor with a little pyramid of metal—conductor upon a conductor. They were not ignorant, apparently, of the necessity, too often forgotten in our days, of contriving an issue for lightning in the damp and deep soil; for when the engineers of the Egyptian expedition explored the soil of ancient Thebes, they discovered, with inexpressible surprise, the existence of a subterraneous obelisk. Upon this monolith, carefully buried in the sand, stood an aërial obelisk, which alone attracted the attention for many centuries of successive generations.

The science of the Egyptian priesthood does not appear to have been confined even to the land of the Pharaohs; for the Sacred Chronicles of the Jews tell us

that the Temple of Jerusalem bristled with iron points. Josephus, ignorant himself of the value of the evidence which he has collected, furnishes us with a very remarkable proof of the efficacy of the means of protection employed by the priests of the tribe of Levi. Effectively, he relates that the fire of the heavens respected for more than a thousand years the edifice consecrated to Jehovah. Lightning neither touched the first temple built by Solomon, nor that which rose upon its ruins after the captivity of Babylon.

It was very different—for the province of Judea appears to be much exposed to lightning—when Julian undertook to deny the predictions of the Christians. Ignorant of the Mosaic tradition, and probably also of that of the priests of Isis, which the Neoplatonists had not thoroughly understood, the Roman emperor forgot to put up again the armatures and points of iron which had so successfully protected the two temples before the birth of Christ.

The lightning was not long in destroying the scaffoldings and dispersing the workmen sent by Cæsar; this signal failure of the enemy of the new religion was hailed with joy by the Christians scattered over every part of the Empire.

It is, beyond everything, indispensable to remark that electricity, in its primitive form, is deprived of all affinity in its natural state. It is a substance somewhat transcendental, independent of the ordinary laws of penetrability, for it appears susceptible of accumulating itself in indefinite quantity in any body, without heeding, as it were, the room which its molecules must occupy in space. It does not modify in the slightest degree the aspect of bodies which absorb it, though it gives to them a new power of acting at a distance. It is a marvellous element which resembles the phlogistic of Priestley and Stahl, which, though acting upon our senses, seems to escape the influence of gravitation.

But this neutral electricity is especially remarkable for the surprising facility with which it is decomposed into two elements, the sole ambition of which appears to be that of combining together again, and which agitate the material world in endeavouring to attach themselves one to the other. It seems as if nature had given to the electric matter a species of soul, similar to those Plato speaks of, which are composed of the half of a being, and only find repose when they have met with the other half of which they are deprived. It is impossible to mention any physical, chemical, or mechanical action which is not accompanied by a manifestation of this impalpable, invisible fluid, which develops itself at the surface of worlds travelling in their orbits through planetary space.

II.

LIGHTNING AND ANCIENT PHILOSOPHY.

If we interpret literally the fragments which have come down to us from Anaxagoras, we shall be obliged to confess that this philosopher had a very extravagant idea of the nature of lightning. We could cite the smallest boy in our schools who knows much more, since he had been taught that lightning and voltaic electricity are identical. Since the invention of the electrical machine, are we not at liberty to manufacture a little thunder? Can we not draw sparks with the greatest ease from a Ruhmkorff's coil? Are we not become miniature Jupiters?

However, when we reflect upon the profound unity of essence which must exist between the *moi* and the *non-moi*, between the exterior world and the little infinite which is in us, we shall be more indulgent as regards the opinions of our predecessors. We will ad-

mit that the great men who discovered moral truths by a sort of sublime intuition, cannot have remained ignorant of all the truths pertaining to the material order of things. We will affirm, in the name of reason itself, that there exists a scientific conscience as well as a philosophical conscience, and we shall be more disposed to listen with respect to the teachings of the earliest instructors of humanity. Who will dare to pretend that we depart from the true historical method, if we happen to understand the writings, not only of Aristotle and Virgil, but of Seneca, Lucretius, Plutarch, and of Pliny himself, otherwise than did the scribes of the Middle Ages? Would it not be necessary to doubt the unity of the human mind, if we were obliged to recognize that the men whose genius sounded the depths of the microcosm, remained in the utmost darkness as regards the constitution of the vast universe in which we mark, at each step, as it were, a reflection of laws which enlighten us? Do not both sides of the necessary and infinite reality bear equally the impression of the same universal laws? Can we penetrate profoundly into the science of man without understanding the part which he plays in nature? Can we really understand nature without possessing the notion of humanity, without grasping the laws of the intelligence?

Plutarch tells us that Anaxagoras believed lightning to be produced by the fall of little flames escaping from the stars. There we have, certainly, a very ridiculous opinion. To assimilate the diamonds which decorate the vault of the heavens to smoky lamps!

However, do we not know that a great number of luminous apparitions are produced by the fall of meteors emanating from planetary space? Do we not know that these mysterious regions send us explosive globes, combustible matters of every description?

Can we discern, even in our own times, what belongs

to terrestrial electricity, and isolate it from that which pertains to a world beyond the earth?

The idea of Anaxagoras, based upon the conception of a constant exchange between the elements of the earth and a universal medium, appears infinitely more fruitful than that of the isolation of our sphere—than the doctrine of void and of chance. Do not let us deal lightly with those who believed in the permanence of the generative forces of the globe.

Perhaps the theory which admits a cosmical origin for the celestial flames was not uselessly disseminated in the world? Who knows that it was not from this despised source that sprang the grand idea of Chladni, which permits us to imagine stars crystallizing in the limpid waves of an ocean of azure wherein suns whirl round?

On the contrary, according to Anaximander, thunder belongs altogether, as to its causes, to the world which we inhabit. It is produced in the very bosom of the clouds which roll over our heads, by a species of internal explosion. The noise is the result of a detonation, which this great philosopher appears to have analyzed, and which must have appeared singularly marvellous at an epoch when gunpowder was not yet invented, when even Hiero had not yet suspected the expansive power of steam.

This theory is far from sufficient to explain the phenomena so complicated as those we have to examine, but it appears, nevertheless, to be the result of profound science and careful observations. Do we not often see a mass of the most compact vapour lower itself until in contact with the waves, as if the floating mountain obeyed some powerful influence? Do we not as often remark, in spite of ourselves, that this mass is broken up into fragments, *as if* the fuse of the blasting had *been ignited by some* invisible miner, and had produced

before us its formidable effect? Sometimes regular atmospheric bombs are shot out by the clouds. We see black and lazy nimbi descending, and incandescent balloons drawn by indivisible motors: nay more, a chariot of fire, escaping from the tumultuous masses, comes and wrecks itself upon the shoals of the aërial ocean. This frightful object explodes with a terrible noise, disseminating terror among the poor reasoning animals who move and eke out their existence as best they can upon these shoals! Again, dare we blame Seneca for having admitted that lightning is produced simply by the collision of clouds? Do we not see, over and over again, the tumultuous masses precipitating themselves with indescribable fury against one another? Does not this frightful agitation account for the marvellous effects which rise before us when the electric flash makes its apparition in the dark sky?

Do we not know, on the other hand, that the clouds contain heavy bodies which menace our crops, our houses, our lives even? Do we forget that there have fallen occasionally from the higher regions of the atmosphere, pieces of ice, so heavy, we are told, that a man could scarcely lift one of them from the ground? Should we not excuse those who have imagined that rocks of solid water could really produce gigantic flames, analogous to those which the iron shoe of a horse causes to dart from the sandstone pavement of our streets, or from the macadam of our boulevards?

We shirk the task of imitating Lucretius, in whose magnificent verses are exhibited so beautifully the theories of Epicurus relating to the formation of tempests:

> "Quick lightning flies, when heavy clouds rush on,
> And strike as steel and flint, or stone and stone:
> For then small sparks appear, and scattered light
> Breaks swiftly forth, and wakes the sleepy night:
> The night, amazed, begins to haste away,
> As if those fires were beams of coming day.

And first we see the light, and then we hear
The noises; these but slowly reach the ear:
Because the images of things do fly
More swift than sounds, and quickly strike the eye:
One instance clears it; for, observe and see,
Whene'er a cruel axe does wound a tree,
The tree straight sighs; but if at distance shown,
We see the stroke before we hear the groan:
So whilst the noise moves slow, the winged light
Flies swiftly on, and strikes the distant sight;
Though both arose at once, that moves the eyes,
Before the slow-tongued thunder speaks, and dies."

The smallest fragment of the statue of the Olympian Jupiter would suffice to enable us to recognise the chisel of Phidias, for creative genius imprints itself in an indelible manner on every particle of the marble which it sculptures. Why should the naturalist confound with vulgar works those remains of ancient theories which have come down to him through the mist of centuries? Should our critical spirit treat marble better than the mind itself?

Let us endeavour, then, to separate the opinions of the great philosophers from that rust which ages of trouble and trials have accumulated, and which prevents us from contemplating their grandeur. Do not let us imitate the indifference of those who treat of the works of these first teachers of humanity, as dreams of no consequence, who accept them without striving to understand them, such as they have come down to us through a period of ignorance. Do not let us voluntarily deprive ourselves of a vast mass of inestimable information. Who knows but what we may find among these ruins a spark which still burns!

III.

THE NEUTRAL FLUID.

We are scarcely less embarrassed than the ancients when we wish to give a theory of the beautiful phenomena of lightning. In fact, it is not sufficient to invoke the vibrations of the ether of our physicists, of that substance which acts perhaps upon matter like the water of an ocean might act upon bodies which are plunged in it! We must admit that a species of universal fluid is susceptible of associating itself with the substance of bodies, that it can accumulate, can become rarefied, concentrated, and disappear with marvellous facility.

Whatever name we may give to it, this universal fluid may be considered as resembling the spirit of nature, unattainable and terrible spirit, subtle fire which, according to Goethe, ascends and descends, comes and goes, appears and disappears. If this marvellous element did not leave occasionally some traces of its passage, we should ask ourselves if we are not dreamers or visionaries when we believe that we see it shine. It seems as if it belonged to an almost immortal world, that it is a sort of transition between the sensitive substance and intelligible truth. By itself it is nothing; but acting through the atoms of Epicurus it makes itself manifest at once to our senses and to our reason. May it not be hidden in those surprising manifestations—in that universal magnetism, celebrated by Kircher?

IV.

THE TWO COMMON RESERVOIRS.

De Saussure, Becquerel, and a number of other observers have shot arrows towards the clouds, as the tradition, to which we have already alluded, tells us that the Thracians and the Hyperboreans were accustomed to do. But the projectiles of the modern philosophers were furnished with a conducting wire in communication with an electrometer. The gold leaves enclosed in the glass case of the instrument always showed a notable deviation in these circumstances, betraying the electric state of the air, and enriching science with a discovery of the greatest importance. On the contrary, the useless tentatives of the ancients must be ranked with the blasphemies of Ajax, son of Oileus, as practices both needless and superstitious.

Observations made during balloon ascents have produced no less decisive results; for the wonderful fluid is not only spread through the lower regions, like the watery vapour, which requires heat to give it wings, and does not forsake the immediate neighbourhood of the earth's surface. Precisely the contrary, we find that it increases in energy or tension as we mount higher into the atmosphere, and none can penetrate to the limits of its power.

For a long time we could scorn the opinions of the Stagyrite who believed that the earth was enveloped in an eternal fire, in the most pure of the four elements, the only one which is incorruptible. But a thick layer, active with electric fluid, the igneous substance *par ex-*

cellence, seems to inundate the higher regions; an immense force appears to reign at the limits of our atmosphere, as Aristotle taught his pupils, two thousand years before the day that the court astronomers caused the king—himself a sun—to admire, for the first time, an eclipse of the moon.

The earth, also, is impregnated with an equally energetic fluid, brother, or rather irreconcilable enemy of the former, as Ormuzd was to Ahriman. Opposite in its properties to that which reigns in the higher atmosphere, it seems to take advantage of the fogs to escape also from the soil and rise into the air. Its manifestations are numerous and powerful, so that it appears quite worthy of measuring its strength with its eternal adversary.

The ancient sages had recognised the impossibility of comprising in a single principle the transcendent nature of their creating gods. They divided them into two persons, inseparably attached one to the other, and nevertheless essentially distinct. Why should we not do for electricity what they did for the male and female gods of India?

We will therefore boldly admit with Peltier, one of the most celebrated physicists of this century, that two substances divide between them the empire of the world.

If we may be permitted the metaphor, we will add that it is the female principle which impregnates the earth Ceres, the eternal spouse of Chronos. On the contrary the masculine energies, carried on the wings of the Zephyrs, fill the highest reservoir.

The Aurora Australis will appear to us to shine with a perfectly feminine grace; but we shall say that the colours which decorate the nights of the Northern Pole have something which reminds us of force and violence.

This is not all, however, for these two principles which seek each other, which call upon each other with noise, which are attracted furiously, are nevertheless separated by a rampart that cannot be scaled. Strange contradiction! It is impossible not to recognise that this inert *rôle* is assigned to atmospheric air, to the element which sustains our life, which warms and purifies the blood in our veins.

Sometimes the pressure exercised by the intermediate layers of air becomes too powerful to maintain the absolute separation of the two electricities. The movement of the earth in its orbit, its diurnal rotation, the storms which burst out upon the solar photosphere, unknown circumstances connected with the mysterious life of our sphere,—in fact, a multitude of causes,—produce febrile fits of affinity between the two substances which tend constantly one to the other.

We are like so many little isolated rocks lost in the immensity of an invisible ocean. By shocks and intervals we become aware of the existence of a hidden world which surrounds us everywhere. Such are the rocks of our coasts when the waves of the immense ocean break against them with fury.

The celèstial fluid acts at a distance, through our atmosphere, it agitates the igneous substance shut up in the earth; storms arise when the astronomical movements increase its mass or its intensity. The unknown influences which operate in the depths of the earth are not less capable of provoking the activity of the electricity which circulates above the clouds, a hundred thousand yards away.

It is a wonderful correlation that nothing which happens under our feet can escape the watch which the higher fire keeps over everything which breathes.

The intermediate regions cannot modify their conductibility without producing numerous, rapid, noisy,

luminous exchanges. Sometimes it is the fire of the heavens which descends to the earth, at others it is the terrestrial fire that mounts towards the sky. Occasionally, we have no doubt, each of the elements makes half the journey, and they meet.

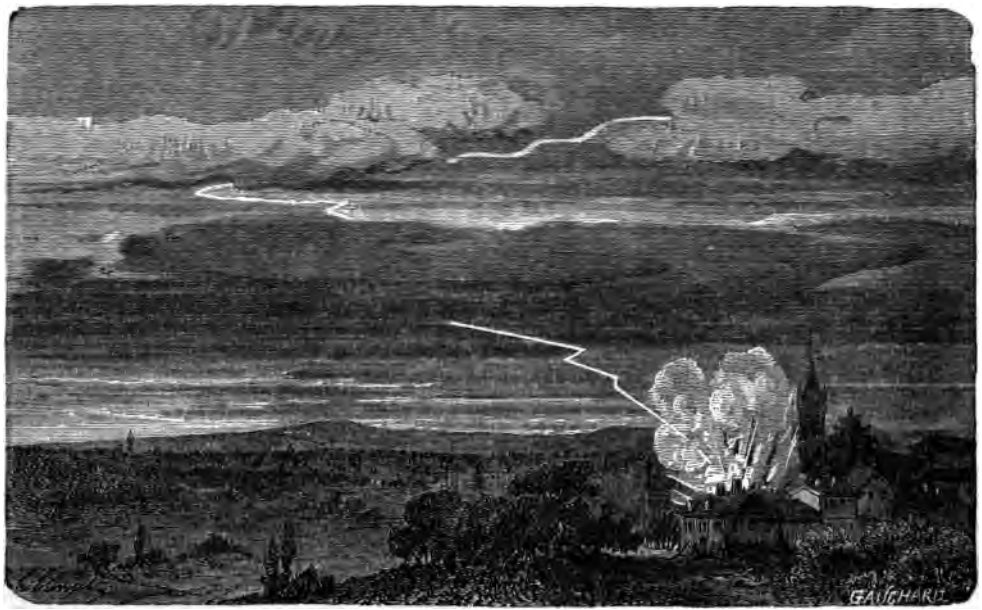
At times a burning fluid escapes from inert objects, an irresistible flame rises from water, from stones, from animated creatures themselves. The marvellous apparition produces the same effects as the flame which descends from the heights of the firmament. Almost always it is impossible to say whether it is the earth which has struck the sky, or the heavens which have challenged the earth.

Does it not seem as if some spring had been put out of order in the admirable machine of the world? If it is thus, be assured that the Architect preserves at least an attentive neutrality; that He hastens to interfere whenever the state of the affairs of nature appears to require an energetic act on His part.

If we admit the hypothesis of Peltier, the existence of two reservoirs, we can compare ourselves to prisoners enveloped in flames, to ants inclosed in the external armature of a Leyden phial.

What should we say of their intelligence or their reason, if we saw that these poor recluses neglected to inquire about the tension of the fluids pressing on each side of the thin envelope of glass which separates them from death?

We should remark, without doubt, that they showed themselves extremely careless regarding the conditions of their very existence. But, should we really have the right to blame their negligence? Have we not omitted to re-establish the *libri fulgurales* which served as manuals, fifteen centuries ago, to the ancient Augurs? Our philosophers, who give themselves so much trouble to collect the smallest rain-drop, to measure the



Different kinds of Lightning.

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slightest elevation of temperature, to determine even the force and the direction of the wind, have they not neglected to verify these oscillations of atmospherical electricity, and even to estimate the magnetic power of the earth? It would appear so at least since they are so silent!

Aëronauts who have risen to the regions of the highest clouds have remarked that they are composed of an infinite multitude of fine needles of ice, almost microscopical. But these ice atoms, evidently, would not have the power of floating in the heights of the atmosphere unless they were sustained there by the powerful affinities of the higher fire, of the marvellous element which reigns at the limits of our atmosphere, at the frontiers where the planetary medium commences. It is then the electricity above which peoples these ultimate solitudes with innumerable legions of diamonds, almost invisible; with drops of water marvellously sculptured by eternal cold!

It often happens that electrical harmonies betray themselves by luminous harmonies. When the former causes the facets of the ice crystals to take certain regular directions, we perceive the meteorological phenomena known as parhelia, anthelia, and lunar haloes.

Although the cirrhi clouds show themselves to us in the form of light filaments scarcely perceptible even when the sky is pure, certain German physicists have calculated that their breadth is enormous, and their length incredible. These white streaks which enamel, as it were, the dark blue sky, contain, perhaps, more crystallized water than the rafts which descend from the Pole carry ice and snow.

The marvellous fluid holds then in its hands what we might call the branches of nature's chandelier. If nature abandoned them, we should soon be able no longer to appreciate the harmonies of terrestrial life; our eyes

would be wounded by light too vivid or by darkness too intense.

But this celestial fire which is seated in the higher atmosphere does not restrict itself to holding suspended above our heads the charming curtain of carbuncles which pulverize the rays of light, causing them to undergo a sort of preparatory division. If natural electricity ceased for one instant to exercise its duty, the ice dust would fall in the form of rain, and would inundate every plain on the globe. Let us cease then to be astonished at the power and energy of certain flashes of lightning. For do we not perceive that they are derived, more or less directly, from that force which, we may say, keeps the flood-gates of heaven closed,—from that fire which saves us every moment from a perfect deluge?

V.

CLOUDS AND ELECTRICITY.

"Let us show for some minutes to the sight of man our face, which changes every instant, and which, nevertheless, will last to all eternity! Let us go forth trembling from the bosom of our father Oceanus! Let us scale without loss of breath the snowy summits of the mountains! Let us remain on these heights whence we can see no longer our image reflected in the azure mirror of the seas! When we no longer catch the deep murmurs of the waves, we begin to hear the sublime harmony of divine streams. What a marvellous part we play! Have we not received at the hands of Jupiter the mission of causing to shine before the eyes of men all the riches of the firmament? It is also from our fruitful breast that fall the rains which put in motion the cycle of terrestrial life. Again, is it not we

who protect the whole of living nature from the most cruel of destinies? Is it not our light envelope which separates the living world from the pitiless cold of eternal death?"

Here we have, certainly, magnificent language, the splendour of which it would be difficult to surpass. It was, however, the language employed by Aristophanes, who gave it to the clouds in order to ridicule Socrates and his philosophy. He prepared the road for the poisonous hemlock!

Electric Clouds stopped by a Peak.

Who could boast of painting what we might term the life of the celestial vapours? Here we have some parasite *clouds attaching themselves* to the summits of *peaks, and which I will* compare to the hat of Mour

Pilate. A little farther on you will see smoke which ends in being dispersed as if vanquished by the importunities of the wind, but not without having strongly protested by a violent roll of thunder!

Boussingault describes clouds which appear to have established their perpetual domicile near the cones of trachyte rocks which constitute the Andes. Humboldt teaches us to admire their depth, the difference of their tints, their shades so dark, we might almost say, so heavy. Could we not easily believe, indeed, that there was something earthy in their mass? Is it not that which caused Peltier to say that they are charged with negative electricity, escaped from the lower reservoir?

At the side of these masses, which might be thought essentially vulgar, we see shining light white bodies like snow, all but self-luminous, perhaps formed of light alone; these appear to be capable of spreading perfumes as sweet as that of the blushing rose.

In the second half of the 18th century Beccaria fixed upon one of the roofs of the Valentino at Turin, two thick metallic wires supported by isolating buttresses, which showed him that an immense force is stored in these clouds, whatever may be their forms, their colours, or their height.

Indeed, before the storm burst forth above the vast edifice, the two wires gave, each of them, a continuous series of electric sparks. The illustrious observer estimates that there were no less than ten per second, and that the least of them was powerful enough to make itself felt from the hand to the elbow. As the Valentino is crowned with seven similar pyramidal roofs, we may suppose that each of these roofs withdrew an equal quantity of fulgurating matter. The smallest storm-cloud gave, therefore, a flame capable of dealing death to at least three thousand men in a single hour, before it had produced the slightest thunder. How many build-

ings and mountains, more efficacious in this respect than the Valentino, are not operating thus to diminish the danger caused by the accumulation of the electric matter in these marvellous nimbus clouds! We should be constantly in terror if we could appreciate the immense masses of fire which filter through the substance of our lightning conductors.

We might as well imitate Æsop, who proposed to his master Xantippus to exhaust the ocean, as endeavour to extract the terrible cargo of electricity from these clouds thousands of yards thick, which cover thousands of acres.

However, the genius of man is so audacious in his struggles with nature that it is with the intention of exhausting the fulgurating force of the clouds that lightning conductors are caused to terminate in a point.

VI.

THE FIRE OF ST. ELMO.

PLUTARCH relates with enthusiasm how the sailors of Lysander saw a fire place itself upon each side of the barge of their captain, the moment that he quitted the port of Lampsacus in order to surprise the Athenian fleet in the waters of Ægos Potamos. It was, according to the credulous and learned historian, the prediction of the victory which was about to deliver up to the city of Lycurgus the empire of Peloponnesus! Procopius tells us, with no less enthusiasm, that the lances of the soldiers of Belisarius shot out sparks whilst this immortal general was preparing his great expedition against the Vandals. These fires announced to the people and senate of the second Rome unhoped for success *in the war which they* even trembled to undertake! *The ancient historians* never omit to mention with

minute care phenomena owing to natural electricity. Although a strong-minded man, Cæsar does not neglect to inform us that the spears of soldiers of the fifth legion appeared on fire during the African campaign, which he undertook after that of Pharsalus, to crown the new-born edifice of his imperial fortune. Did not Castor and Pollux (for it is thus, as we all know, that the ancients called the fire of St. Elmo) announce to him that he would soon disperse the remainder of the Pompeyan party?

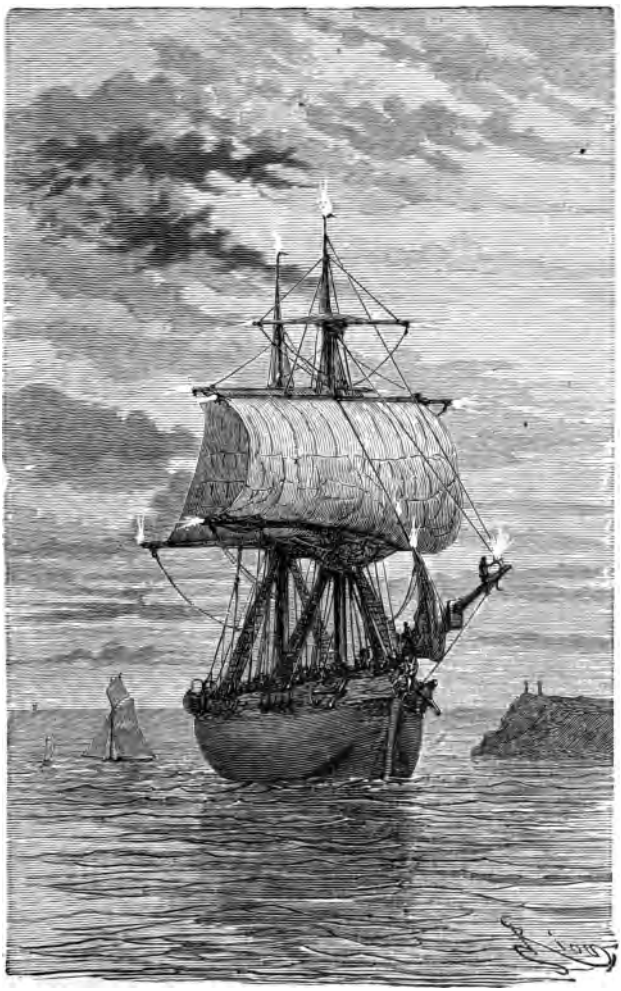
Seneca relates, as a strangely significative warning, that a star came and hovered over the shield of Gylippus when this general prepared to fight against Nicias and Demosthenes, the two Athenian generals of the siege of Syracuse.

We notice the fire of St. Elmo again, upon the threshold of modern history, associated with one of the greatest events that was ever accomplished on the surface of the earth. Celestial lights appeared, says the chronicler, at the point of the main mast of the ship in which was Christopher Columbus, in October, 1453, during the voyage which he undertook to conquer the new world he had so recently discovered.

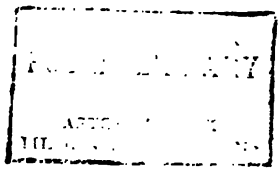
In our days sailors still attach a certain importance to such signs; for they suppose that the apparition of these natural lights generally indicate the end of the storm. Are they wrong if it be true that electricity is the hidden motor of the tempest?

This luminous matter is sometimes so abundant that it appears to give rise to multitudes of furious flames, which escape from every point with an alarming impetuosity. The following adventure, which happened to Forbin, is quoted in several works on Physics; it occurred during his campaign in the Balearic Isles.

The night was dark and with no moon, the sky rent with lightning and thunder announced a violent storm.



The fire of St. Elmo. 41



Suddenly the accomplished sailor saw a fire of St. Elmo appear, crowning the weathercock of the main mast, as might have done a large flag woven in luminous matter. At the same time a number of streaks of flame escaped from different points of the mast. The admiral did not ask himself whether this was not a warning which announced the taking of Port Mahon, but he imagined that he might extinguish the most menacing of these flames, an immense incandescent plume which frightened him, and he endeavoured to take away the iron rod which terminated the main-mast of his ship.

Is it necessary to add that these rather puerile efforts had no result? The flame appeared on the wood as it appeared on the metal. It only disappeared when the storm had entirely dispersed.

We have had executed the accompanying drawing of a similar apparition which occurred in the month of March, 1866, on an iron ship sailing in the English Channel. On this occasion the captain distinctly saw a blade of light, not only at the extremity of the main-mast, but at the end of every yard. The most vivid of these flames emerged from the bowsprit. The captain, who was acquainted with the properties of the fire of St. Elmo, did not dream of endeavouring to stop this production of light, but he had the curiosity to study it closely. He therefore climbed to the point where the fulgurating matter shot up into space.

Rather moved, no doubt, by the novelty of the spectacle, he approached his hand to the marvellous focus; his surprise soon became very great when he perceived that the flame radiated no appreciable amount of heat. Moreover his own body serves to conduct the fluid, his hands become electrical. O marvellous! it is now from the *extremities of his* fingers that emerges the fire *which leaps into the* air. He feels no shock however,

he experiences no commotion, though he acts as a living conductor to this current of fulgurating matter, fire which escapes during the whole time that the tempest lasts. How many thunder-claps might have been fed with the substance which passed in a few hours over his body! Never before, perhaps, had the intimate connexion of the fire of St. Elmo with thunder-storms been so completely verified; for the jets of cold flame followed faithfully all the variations of the storm. Each time that the wind increased, that the rain fell with greater fury, the innocent light was seen to increase in splendour.

The next day they hastened, naturally enough, to examine the masts and yards which had supported all these lights; it was found, with much surprise, that they had left no appreciable traces neither on the paint nor on the varnish itself. If the passengers on board the ship had not witnessed this phenomena, the captain would have been considered by others as the victim of an illusion, probably by himself also.

What, indeed, can a man think of his own intelligence when he alone sees what the crowd refuses to see? Is there not a Rubicon which also separates genius and folly? We often feel that we are passing this Rubicon, but, alas! in which direction?

Oftentimes these lightning flames are invisible, and slip away unobserved, without any indiscreet spark revealing their presence; but sensitive photographic paper then acquires traces which chemistry can render indelible. The following fact may serve as a lesson to those who believe that they see everything which occurs around them on this world. A photographer of Berlin had taken a negative image of the bronze statue of an Amazon vanquishing a serpent with her lance. On obtaining the positive proofs he was excessively surprised to see a dark streak standing out from the upper end

of the lance. An obscure invisible lightning flame, but endowed with immense photogenic power, had occurred whilst he took his photograph of the statue. He had taken in the act an anonymous fire, and had photographed, without knowing it, the first flash of lightning that was ever fixed upon sensitive collodion.

VII.

MYSTERIOUS AUREOLA.

THE ancients, who introduced thunder into all the acts of public and private life, could not suppose that it would neglect to make itself heard on great occasions, at the birth of heroes, princes, great men or famous blackguards.

There were, consequently, in the hands of Jupiter lightnings in reserve for every event, for every occurrence, auspicious or inauspicious, present, future, or past.

The art of the Aruspices, exceedingly complicated, as everyone will readily understand, consisted in distinguishing in this chaos of luminous manifestations, the true meaning of the sparkling hieroglyphics.

The history of imperial Rome would suffice to show how difficult it must have been to become a good interpreter of these signs; so that the perplexity of the ancients could not have been less than our own.

The birth of Augustus was announced by warning lightnings which struck the walls of Velletri, his native soil, at the moment of his birth. Later the lightning flashed again, but it was to express the condolence of heaven when Cæsar fell pierced with the poignard of Brutus.

When this prince ceased to make the Roman people

happy, Jupiter was again moved, says Suetonius, doubtless not wishing to deprive the empire of its guide without warning the world by some striking sign, the god sent down lightning upon the capitol. It struck away, they say, the first letter of the name of the prince from the legion of statues which, having little modesty, he had caused to be erected during his lifetime.

Even the death of Claudius, that emperor who scarcely knew how to be ridiculous, was also the occasion of a thunder-clap! Sometime before the event the fire of heaven fell upon the statue of Drusus, the first husband of Agrippina, that model of spouses! It must have been necessary, however, to have been profoundly learned in the science of augurs to see in this a sign destined to prevent the Roman people from reckoning too much upon the happy commencement of the reign of Nero!

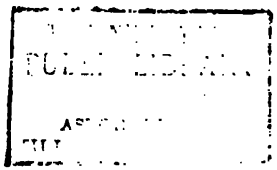
With the help of a little imagination is it not possible to see anything we wish in these strange coincidences which nature offers to us in infinite numbers?

Thus, in the storm of 8th April, 1866, we see the lightning fall in an immense number of different places, as if the lightning-conductors had been all suppressed for the sake of economy. An Aruspex would doubtless not have failed to see, afterwards, in these innocent and repeated thunder-claps the anouncement of the neutrality of France, looking on in the presence of gigantic events.

What would be said, if we were desirous of resuscitating the science of the augurs, of the magnificent peal of thunder which roared whilst Herr Bismark harangued the people of Berlin after the victory of Langensalza? Should we not be tempted to cry out, as this minister actually did, with much apropos: "What! do you not see that heaven is with us?"

With how many facts and coincidences the history

Electric Aureola. 47



of these events would furnish us, especially when we remember that a drenching rain accompanied the procession of the Viennese on the eve of the battle of Sadowa, going to invoke, for the imperial arms, the divine blessing?

But it is when the electric matter flows quietly towards the heavens, and takes for its pole the body of man himself, that the spectacle is truly marvellous. Imagine, in fact, a flame spread out in form of an aureola, something like the glory which surrounds the heads of saints in pictures! The annals of every people make mention of apparitions of this description; it appears difficult to doubt their authenticity, however desirous we might be of doing so.

When the Trojans bewailed the death of Creusa flames appeared on the head of the youthful Ascanius; the old Anchises—and who would not have fallen into the same error?—believed that he foresaw in this the future in reserve for the race which would emerge from his grandson and revenge the ruin of Troy.

Livy relates that Servius Tullius was seen enveloped in flames in his crib, when his mother was a slave of the king Tarquinius Priscus.

It is incontestable that these strange phenomena are not entirely contrary to physical principles, and that philosophers and sages might be more or less favoured by the hidden lights of nature. Nothing prevents our supposing that nervous impressionable individuals, as the interpreters of dreams or visions generally are, may be such good conductors of electricity as to occasion these spontaneous discharges of electric fluid. Perhaps there exists constitutions which are exceptionally remarkable in this respect, and are consequently susceptible of provoking the flow of electricity from the soil, *and thus to rival, to a certain extent, bad lightning-conductors.* Humanity is a complete world in itself,

and we were right to call it the human kingdom. It is between man and man that we observe, sometimes, differences more striking than any we meet with in the whole of nature.

VIII.

SHEET LIGHTNING.

When the electric fire lights up the surface of our atmosphere, at the boundaries which separate us from the ethereal ocean, it is not in a disorderly manner; the apparition is replete with harmony, grace, and measure. Shining through an immense thickness of the respirable medium, the aurora borealis causes us involuntarily to dream of the splendors of Olympia.

A high arch of iridescent light, a majestic vault of more than twenty leagues span, shows itself effectively to our astonished eyes. It is an admirable cupola, a fairy canopy, which entirely surrounds the spherical cap, on which is found the magnetic pole of the earth. Long streamers, equally woven in this subtle matter, spread out from the marvellous canopy.

Nevertheless these divine fires are the brothers of our most violent and most abrupt lightning; it is the same lightning that spreads itself out above and produces these marvels, which, nearer to us, condenses itself into sharp darts and whirlwinds of flame. It is—who would imagine it?—the same substance which is in motion under the influence of the same mysterious forces. If ordinary lightning has lost this harmonious character it is because it has approached nearer to us. Either it has assimilated some of our imperfections, or the harmony, in too close proximity, escapes our feeble reasoning powers. Does not distance throw a veil over details in order that we may recognise an unchangeable

law, and not lose ourselves in the infinity of things proportioned to our own size! As they descend lower so they become more terrible, as if they participated to some degree in our miserable human passions. But, luckily, there are many degrees of degradation through which the sublime fire of the higher atmosphere can pass before it is changed into brutal and vulgar lightning, like that which flashes through the thick air of our lower regions. The electric spark propagates itself still without much noise and without much effort in the intermediate regions, amidst the light cumuli. An eagle, an aeronaut, who happened to be overtaken by those large widely-spread, diaphanous flames would never believe that he was sailing in the midst of sister-flashes to those which so often spread fear over the earth. Among the observers who have studied their distant reflections, viewed through the fissures of a nimbus, all have not understood the excellence of their inoffensive nature. How is it possible they could only see in these soft and tender flames the reflection of our lightning of the lower regions, of that fire which scorches, burns, and kills! And what matter the proofs? it would be as philosophical to believe, with maidens and poets, that it is heaven which opens! In the theory of lightning, which speaks so clearly to the heart and mind, it is not always contemporary science which triumphs in the regions where float the cirrhi.

Has not the Prussian Giessler invented marvellous tubes, in which we see with what facility electricity circulates in a wide sheet as soon as the air becomes less dense? Up above the obstacle is suppressed. For discharges which occur in a medium of sufficient conductibility are incapable of giving birth to detonations, or troubles of any kind. As long as no resistance is offered to it, electricity plays softly around bodies.

In most cases this poetical and graceful lightning

shows itself in a disorderly manner, without any palpable motive. We see it illuminate every azimuth. Sometimes, on the contrary, it appears to obey some law of direction, of a magical order. An English observer made this remark when studying one of the storms of June, 1866; the centre of emanation, which appeared to be fixed in the north-east, passed suddenly to the south-west.

In the same month of June, 1866, an English astronomer observed that numerous, immense, and brilliant flashes of sheet-lightning appeared to emanate from a central point, the movement of which he was able to follow for more than an hour: perhaps a distant storm.

Let us not suffer then from puerile terror when we see the light clouds of the intermediate regions exhaust their celestial artillery in struggling against one another. Far from being considered as hostile to us, how welcome is sheet-lightning! May it often announce to us the annihilation of thunderbolts which could not have descended among us without reducing to ashes our palaces and our cottages.

These clouds exchange lightning which does not threaten us, It resembles the brilliant tournaments of eloquence between politicians. We other inhabitants of a distant land, only perceive the reflections of these combats, and we find that they resemble games of play.

IX.

SPARKLING CLOUDS.

ALTHOUGH reduced to invisible vapour, the water which descends towards the lower regions does not appear to give up its part of universal tranquillizer, or mediator of the physical world. Does it not, in fact,

operate almost always as temperator, not of cold and heat only, but of the bounds of electricity; how much frightful thunder can it not spare us?

As soon as the air is charged with moisture the fulgurating substance of the higher régions commences its connexions with that which is down below. With what activity the clouds work, when we believe, poor mortals, that they are asleep!

Here are vapours which spread themselves out in thick layers, and appear to press upon us with immense weight, though the barometer experiences a marked depression. Do you not see them as they float above our heads? Do they not appear to strike all nature with stupor? Do they not produce an universal torpor? Nevertheless, this repose, so complete in appearance, so cheering, is only a deception. These tormented masses, whose supineness we now admire, it will suffice to examine with a very weak telescope, to discover that the most indolent of them are precisely those which are a prey to the most extraordinary fermentation. It is only up above that we shall find unruly activity

Vapour now rises and descends at the same time, it is formed and disappears at once. The cloud sends into the air threatening horns, which are withdrawn no less rapidly, unless an invisible gust of wind tears them away and disperses them in the distant atmosphere.

One would imagine that a feverish life animated these nebulous masses, if it were not evident that life requires more stability to show itself. These clouds, tormented and tormenting, are the ordinary vehicle of terrible electricity, that which attempts to descend towards the earth. They are, in a manner, the defects of the atmospheric armature which represents the glass of our gigantic phial.

However, even in this case, the discharges are not all of a fulgurating nature; the air always yields when its

molecules can roll rapidly one over the other! It is when the whims of electricity demand a still greater velocity that the air resists strongly enough to produce a rupture. How often have we not seen beautiful flames, soft and calm, more poetical still than the sheet-lightning, enveloping the borders of vesicular masses! Nicholson and Beccaria have had the honour of describing to us this splendid livery of the lower clouds: if they have really observed them, they must have been clever enough to have viewed them as transparencies against a thick cloud acting as a screen to bring them out!

You will see them certainly more than once, shining between two claps of thunder, these trembling lights, these aerial will-o'-the-wisps, if you will imitate their tricks, and the perseverance of the two observers just named. What marvels does nature not possess for those who know how to see them! When will some poet of sympathizing genius be awakened from his dreams by the mysterious apparitions that physicists are not capable of describing! Certainly he would teach us to love them, to cherish them. Let him share with us some of those sweet deep thoughts which such a spectacle cannot fail to awaken in his soul!

It requires a pen accustomed to make use of all the delicacies of language in order to describe these phosphorescent clouds, veils of light which appear to be jealous of no other light, for they allow the least brilliant star to be seen between them. But do not let us forget that if this fulgurating matter, this sparkling treasure which escapes from the clouds, shines before our eyes, it is because watery vapour acts towards it both as a veil and as a conductor.

Do you not admire this association of two elements which we are accustomed to consider as averse to one another? Here we have water and fire living together

in mutual harmony. Is it not also electricity, celestial fire, that suspends the needles of ice in a region of cold so prodigious that our thermometers refuse to measure it? Thunder and lightning will show us many other marvels presently.

If we wish to understand how clouds can cover themselves with a divine phosphorus, we have only to repeat an experiment well known to the older physicists. Evaporate a few drops of water placed in a capsule to which we have added some black liquid. We shall recognise without much difficulty that the masses of vapour thus produced are composed of an infinite number of minute balloons. Each of these little globes is formed of a light envelope of liquid, and hovers about, independently of its neighbour, from which it is separated by a small layer of air. The dew which deposits itself upon the plains of the air is not formed otherwise. Myriads of these little balloons hover side by side and in harmony above our heads. They rise or fall according as the atmospheric layer beneath them is warmed or chilled. These alternations picture to us all the vicissitudes of temperature, like a wonderful thermometer which functions of its own accord.

Sometimes clouds conceal on their edges a great quantity of electric matter. Too often we see them send forth dangerous thunder-bolts! But whilst awaiting the explosion the ever-active fluid cannot remain still; it springs from one vesicle to another. It plays wildly as we see it when it rushes along the surface of the sparkling condensors of our laboratories.

Each of these sparks is, moreover, an assuring testimony, a proof that the nimbus has not forgotten its tutelary care, even when it has accumulated above our heads and seems swollen with menaces.

Thanks to these clouds, to these ofttimes invisible *vapours, heaven and earth* exchange, without danger, their

frequent caresses. How often should we be completely unaware that electrical masses are neutralizing each other if we did not experience an inexplicable feeling of satisfaction and enjoyment, produced by the quieting of these mysterious affinities. Arago's testimony not only confirms the reality of the illuminating power of this disseminated electricity which springs from vesicle to vesicle, and decorates, as we have just seen, the lower surface of clouds, but he relates that the subtle fire actually marries itself to liquid water itself, to the waves of the ocean. Lights have been seen to emerge from the crests of the waves, and to illuminate the shores of the tropics!

It appears difficult to explain this phosphorescence by the simple work of legions of infusoria which have, nevertheless, been caught and seen to shine in the hand; it is perhaps the indication of some gorgeous phenomenon, in face of which the learned secretary of the Academy could not help exclaiming—"How marvellous!"

His investigating genius, which has revealed to us the rotative, magnetism of an electro-magnet, appears excited on contemplating such magnificent phenomena. He asks whether the light of the sun does not depend upon a permanent engagement between the two electricities of that immense orb. What an image, what a sublime conception! The light which illuminates us and warms us would then depend upon a phenomenon which we can scarcely recognise from the boundaries of our modest sphere! But we are not quite deprived of this aureola which constitutes the glory of the central orb of our world!

What, in reality, is requisite in order that we may admit this hypothesis of Arago? Very little, in truth! Who knows but what the continuous light which the sun sends us would not be so vivid, unless the vapours upon it were so intensely thick!

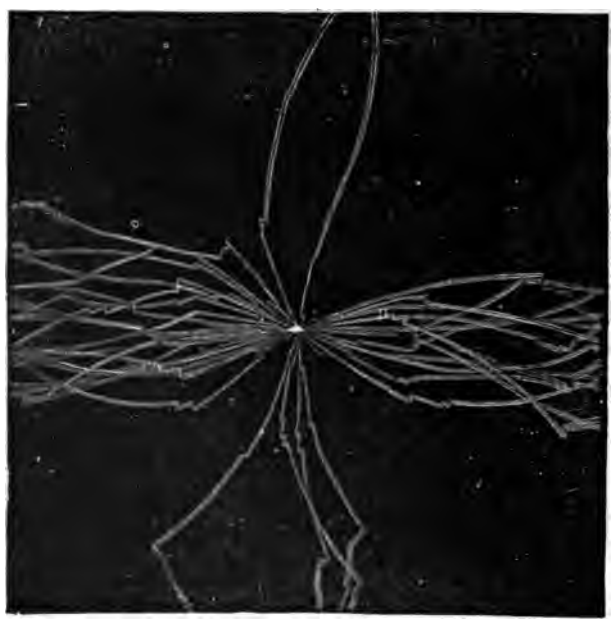
We have certainly good reasons for asserting that the atmosphere of the sun is a better conductor than ours, if we admit that metallic vapours float in it. Nothing need prevent our imagination multiplying the effects immensely, since the dimensions of the sphere are so enormous. But it was not without a motive that the immortal friend of Humboldt restricted himself to sketching this hypothesis in a note, lost at the foot of one of his three or four hundred pages. Let us not be bolder than this, and hasten to descend from heaven upon earth.

Photographic reproduction of Electric Spark.

X.

GLOBULAR LIGHTNING.

LET us suppose certain intelligent fish inhabiting the deepest shoals of the ocean. These reasonable beings, whose organization detains them beneath the waters, see coming the plumb-lines of our engineers. They contemplate at their ease the cable by which certain



Photographic reproduction of Electric spark.

clever electricians have joined together the two halves of the human family, whose very existence they are forced to ignore. What fantastic opinions would they not deliver in their academies, if they had the ingenious idea of assembling in council their philosophers and their sages! Can we believe, seriously, that they would have perspicuity enough to guess the use of the copper wire, the nature of which it would be the more difficult for them to get at, as they are deprived, doubtless, of all the necessary implements wherewith to attack the envelope of gutta-percha, which isolates and protects it?

Let us be persuaded that our physicists were not less exposed to error when they proposed to explain the nature of the globes of fire which descend from the clouds, of those which start from the stones beneath our feet, from the pavement of our footpaths, or the aisles of our churches.

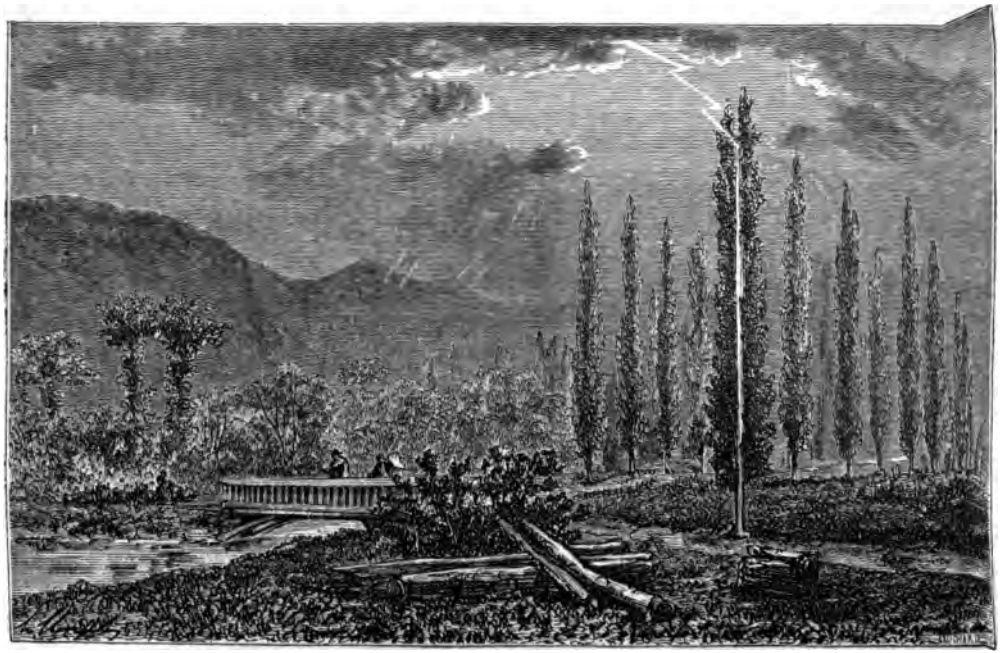
The most simple thing for us would be, evidently, to ridicule the credulity of authors who assert the reality of facts so embarrassing to an honest physicist. Unfortunately our scientific respect for ourselves does not allow us to hide our ignorance. Sometimes globular lightning has been seen to explode in the presence of five or six hundred spectators assembled in a church or in a theatre! Our incapacity will be the more painful to confess, as we cannot attach these extraordinary facts to our scientific ideas in general, as we ignore the nature of the fulgurating substance, as we scarcely know the phenomena of which it is, if not the agent, at least the original material.

The theory of lightning conductors would appear incomplete and abridged if we did not account for the hundred and fifty authentic cases of globular lightning collected by Dr. Sestier in his learned work. The great Frederick will triumph over Franklin if we do not explain why, on the 18th of August, 1777, at 9

o'clock in the evening, a globe of fire some two or three feet in diameter was seen to strike the lightning conductor of the Observatory of Padua. It is no less urgent to explain how the same phenomenon came to be observed in the village of Villers-la-Garenne, on the 18th of August, 1792; how, on the 24th of December, 1821, a third globe of fire smote the lightning conductor of a house at Grabon, &c. &c.

Again, should we hide from ourselves the fact that globular lightning appears to have a special liking for gutters, for the pipes which discharge the rain-water from our roofs; that it loves balconies, and is passionately fond of gas-pipes and other metallic objects with which houses are furnished on so many pretexts? Should we not explain why the globe of fire mentioned by Daquin shot out from the clouds, and, after striking a tower most violently, was caught up by a water-pipe, —what an idea, to come so far, to make so much noise, and then to alight on such an object!—and followed its course quietly from the roof to the floor?

We see in a number of Poggendorf's *Annalen*, about twenty years old, the account of another case of ball-lightning occurring near the town of Cœthen, in the duchy of Anhalt. On this occasion there were a great number of spectators, who all saw the marvellous sphere, which appeared of a clear green tint. Why green? Globular lightning shows itself in so many forms and of so many different tints that we will not endeavour to say why. M. Colon, vice-president of the Geological Society of Paris, saw a ball of lightning descend slowly from the sky and reach the earth along the bark of a poplar tree. It took five or six long minutes to descend from the summit of the tree to its basis, as if it required to overcome the resistance of the air; on touching the soil it bounced up again, rapid as lightning, and disappeared without exploding. What rendered it so solid?

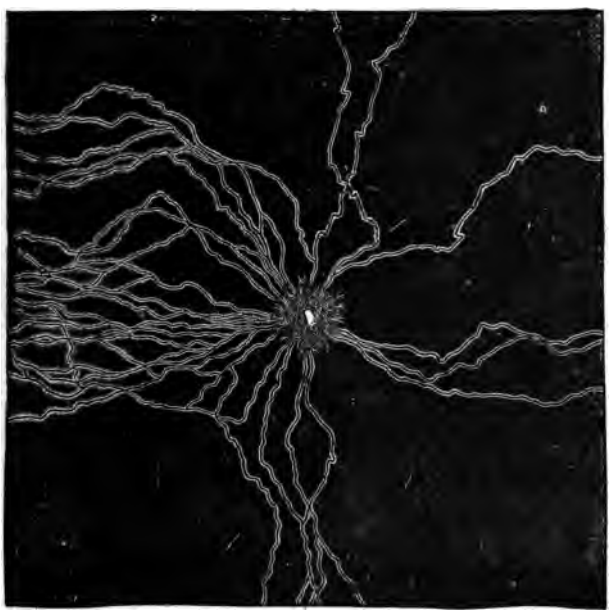


Globular Lightning seen and sketched by M. Colon, Vice-President of the Geological Society of Paris.

Lost in these lower regions, it felt that it was on the wrong road; was the splendid visitor not right in hastening to return to its celestial home?

Sometimes matters do not take such a quiet turn. We see a terrible struggle. The most prosaic individual will think, in spite of himself, of the fire-horses of the fairies, of the shining chariots of the genii!

This is what happened in 1823, in a storm, observed over the Black Forest by Professor Schübler:—Two luminous globes drawn by two blades of flame were seen. The one appeared to be quite at its ease, and drew along its wonderful charge as regularly and quietly as



Photographic reproduction of an Electric Spark.

a cab-horse trotting, by the hour, over the macadamized pavement of the Boulevard; but the other described in the air a host of zigzags, and appeared to be a prey to the most extraordinary agitation. It often appears as if these globes of fire experience a certain repugnance, or have to get over some serious difficulty, when they approach our earthly dwelling-places.

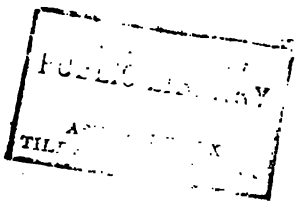
Admiral Duperrey relates that he saw, near the islands in the Baltic, a spherical cloud of terrible aspect, which thundered and shot out flashes of lightning in every direction.[1]

When these astonishing meteors succeed in overcoming the resistance which is opposed to them, they act as if they rather liked to mix in the society of men. About a century ago a German peasant girl was preparing dinner. Suddenly she saw a ball of fire, the size of a man's fist, emerge from the chimney, pass close to her feet without hurting her, and continue its course, respecting even a number of little upright objects which the slightest gust of wind would have overturned. The poor girl rushed towards the door, but the ball of fire came jumping after her.

Sometimes the aspect of globular lightning is so peaceful, so honest, that one might be tempted to treat it lightly or with a kind of bold familiarity.

On the 10th of September, 1845, a ball of lightning presented itself at the threshold of another kitchen situated in the village of Salagnac, in the valley of La Corrèze. Three women who were there experienced no fear in the presence of the strange visitor. They shouted to a young man, near to whose feet the ball was rolling, to step upon it and extinguish it.

[1] A curious case of globular lightning was observed on Loch Scavig in Scotland in the month of September, as detailed in my book on *Phosphorescence*, p. 60; and many years ago, General Sabine observed a very remarkable luminous cloud in the same locality; it also emitted flashes of light. [Translator's note.]



Globular Lightning.

Luckily for him this peasant lad had been to Paris, and had been electrified one day on the Champs Elysées for two sous. He had learnt to respect the mysterious fluid and its shocks; in spite of the imprudent exhortations of the girls, he allowed the ball to pass by. It was fortunate indeed that he did so, for a few seconds later the treacherous sphere exploded violently in a neighbouring stable. It killed a pig which happened to be shut up there, and which, knowing nothing about the wonders of thunder and lightning, dared to smell it in a most rude and unbecoming manner.

The volume of these brilliant spheres is never very considerable. Out of one-and-forty observations in which the approximate dimensions of the meteor have been estimated, in one case only it was stated to be upwards of a yard wide. It is most often compared to the apparent size of the moon, and sometimes, even, to a child's marble.

Almost always these fulminating globes move along as slowly as that which visited the streets of Milan. The curious could walk behind it for three or four minutes before it exploded upon the cross of a clock tower; another iron point! Some who have seen these curious meteors have believed that they were carried along by a slight current of air, so calm were their appearances; they have actually been seen to stop in their course as if deliberating upon which side they should proceed next. A fulminating globe which had rolled towards the door of a drawing-room appeared intimidated by the presence of some persons who happened to be there. It required to reflect for a few instants before advancing to the middle of the room.

Do not trust these meteors, however. Let those take care, who are imprudent enough to participate in the error of the worthy peasant women of Salagnac! For nineteen times out of twenty this globular lightning

spreads around it the most frightful destruction. From the globe of fire which invaded the church of Stralsund were shot out small bombs which exploded with a fearful noise. The fulminating globe of Beaujon did as much harm, and made as much noise, as an infernal machine bursting in a street. It shot out a dozen flashes of zigzag lightning, which struck surrounding objects of every description. One of them made a hole in the wall as a cannon-ball would have done.

Another thunderbolt passed through the wall of a barn at Effeln, and killed two cows and a colt which were fastened to it. A fulminating globe that exploded among a group of peasants in a barn at Everdon, wounded and killed several of them. On the surface of the bodies of these unfortunate creatures were seen a number of lenticular burns.

As we see again, by this passage, it is impossible to forsake the idea, that there exists a species of subtle matter susceptible of uniting itself temporarily with ordinary matter. It is this fulgurating matter which appears to possess the property of dragging in its course incandescent spheres composed of gas collected in the air; it gives, apparently, to these frightful projectiles disorderly and *quasi* voluntary movements.

What, in reality, is this fulgurating matter of which Arago speaks so frequently in his *Notice sur le Tonnerre?* We will not undertake, any more than he has done, to define it. Who has ever explained what life is? Nevertheless physiologists are always speaking of it.

Has the straight line of Geometry been defined otherwise than by enunciating one of its properties? No one however, has called mathematicians to account for this. In fact, when ideas impose themselves words are inevitable; without their aid we could neither think, nor even find a form whereby to fix our ideas in that species of transparent cage called language.

XI.

ELECTRICAL WILL-O'-THE WISP.

ARTIFICIAL lightning which emerges from the Leyden jar or from a Ruhmkorff's machine can be made to take the globular form by means of certain simple artifices. The photographic images of electric sparks, which we have given in the engravings, leave no doubt of that. Could they not be brought forward as an argument in favour of the reality of globular lightning? For we must admit that Nature can realize, in her manner, all the phenomena which we can produce in our cabinets.

Like the globular spark of our physicists, that of Nature travels in every direction, we might almost say from one pole to the other. This curious mixture of electric fire and material substance does not always fall from the skies; it is seen occasionally rising from the bowels of the earth, and it must not be mistaken for the Will-o'-the-wisp which appears in our cemeteries.

On the 2d of July, 1750, the Abbè Richard saw a flame rise suddenly from the pavement of a church. The light rose some twelve or fifteen feet in height, as the phosphuretted hydrogen flame emanating from the brains of the dead might do.[1] On this occasion the flame appeared to emanate from one of the towers.

The meteor which struck a nunnery in the town of Bologna rose from an excavation which received the water of the streets, and it might have been thought

[1] Will-o'-the-wisp never rises more than two or three feet from the soil, or above the surface of stagnant water. [Translator's note.]

that it was formed there by the accumulation of gaseous exhalations: but the shock was so violent, says Barchetonner, that it knocked down a part of the tower on to which it precipitated itself with fury.

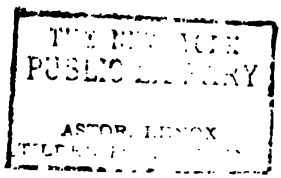
In the midst of a horrible tempest Dr. Gardino saw many globes of fire hovering on all sides. They floated at a slight distance only above the ground, made a sharp crackling sound, and exploded, causing all kinds of damage.

Dr. Sestier relates that these same meteors killed a man in his bed, struck down several animals, broke the trees, and damaged the houses.

We will quote, also among the most marvellous of apparitions, the flame which the physician Maffei saw rise, in 1713, from the ground-floor of the Château de Frosdinaro; for this mysterious substance, of an azure blue colour, appeared to be agitated by a kind of internal wind; suddenly it increased in size and disappeared without leaving the slightest trace of its passage.

Shall we connect this meteor with that which the Abbé Girolamo Léconi de Ceneda saw rise, at the same time, from the soil of a village in the neighbourhood of Venice? He saw a streak of fire come out of the earth, like the preceding one, and float for some time above the spot where it had risen. It soon vanished like the blue light seen by Maffei, but, this time, not without producing a frightful noise which filled the worthy Abbé with intense terror. How do we know, let us ask again, whilst we allude to more recent events, that we must not attribute to the same causes, the flames which accompanied the birth of the little island in the bay of Santorin? And the Will-o'-the-Wisp, and fire-damp itself, are they not inflamed sometimes by the influence of capricious currents, invisible electric flashes, which, as we shall see presently, often rush through the air?

Electric Will-o'-the Wisp. 71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Why does this matter, which disperses itself so easily when it mounts towards the clouds, contract itself into globes when it approaches the shoals of the aërial ocean?

Do we not see the spherical form produced naturally when oil, or other liquids unsusceptible of mixing with water, are stirred violently in contact with the latter? May we not say that gases charged with fulgurating matter are incapable of being dissolved in the air, and put themselves naturally into this particular form when external attractions force them to traverse gaseous layers of increasing densities? Is it not an effect of the same kind which reduces the substance of comets to the form of an elastic sphere, the radius of which diminishes as they approach the sun? Are we quite sure, moreover, that none of our globular lightnings fall from cosmical spheres, that no gaseous bolide can escape, by some extraordinary coincidence, that combustion which destroys the vast majority of substances drawn from the inexhaustible quarries of the heavens by the attraction of our formidable sphere?

But why should we follow so painfully these mysterious analogies in the present imperfect state of science? Often a globe of fire which has passed slowly over ricks of hay and over straw without setting them on fire, which has touched the bodies of men, women, and children without causing them to experience the slightest sensation of heat, has exploded, spreading around a host of burning squibs.

XII.

TERRESTRIAL WATERSPOUTS.

When a cloud is thick enough, tenacious enough, and, perhaps, when the air is sufficiently charged with mois-

ture, the electric matter draws it towards the earth. It is no longer then a simple fulminating globe which precipitates itself with impetuosity towards us; it is a threatening column which descends from the skies. Sometimes this column progresses so slowly that a man can follow it on foot. But one must possess, it will be readily admitted, almost superhuman courage not to fly at once in an opposite direction. For these meteors sometimes break their connection with the earth, and then most frightful and incredible effects are the result. For instance, M. de Gasparin tells us that the waterspout of Courtizou overturned one of the walls of Orange. The extremity of this column of vapour having commenced whirling round like a sling hanging from the clouds, caused a breach in the mass of masonry, the opening of which was thirty-nine feet long, sixteen feet high, and four feet wide. This species of bastard lightning tore up in an instant a mass of matter weighing at least 200 tons.

These turbulent clouds are accompanied by discharges of lightning which should long ago have put observers upon the track of the forces which produce them. Nevertheless it was only when a waterspout ravaged the neighbourhood of Chatenay, about the year 1840, that people began to believe that Peltier was probably right when he said that thunder and lightning had something to do in the business. Why not stop at once at this explanation when we perceive that the only two buildings destroyed by the catastrophe were spinning manufactories that contained a great deal of metallic machinery? Do we not recognise in this choice the ordinary taste of thunder? Moreover, the workmen scattered here and there by the whirlwind were unanimous in declaring that they saw round about them certain mysterious flames. At Malaunay, as at Chatenay, as again at Combaz, thunder preceded the protrusion of

the cloud. But no sooner had the tail of the waterspout begun its descent, than the thunder was silent. The lightning spread itself clandestinely and timidly. It would appear that electricity sometimes concentrates its forces in order to produce a fine spectacle upon earth. Is it not necessary that, from time to time, human pride should be shamed by the unchaining of forces which surpass it? We may fairly say that in this particular form of meteor Nature has neglected nothing whereby to humble us.

It appears difficult to conceive a storm more favourable for observing the formation of these meteors than the frightful waterspout of Malaunay. Effectively, in the early part of the day, two storm clouds approached, driven violently one towards the other by contrary currents. These two masses being charged with the same kind of electricity, doubtless positive electricity, could not amalgamate into one cloud, nor could they discharge each other by giving birth to a brilliant flash of lightning. The higher storm cloud, which appeared the stronger of the two, managed, though not without difficulty, to push down the lower cloud. Who knows but that this happened by the intervention of the earth which, being powerfully electro-negative, attracted the vapour charged with positive electricity? As soon as the horn, pulled from the vanquished cloud, had approached to within a few yards of the earth, its fire was seen to flow from it like a stream which had just found an issue, for the point of the horn was perfectly incandescent. The tail of a waterspout is almost always seen to be luminous when it approaches the ground without coming in contact with it; so powerful is the effort of the fluid which passes from the summit of the cone.

Sometimes the electric tube rises from the earth: in this case it is not watery vapour which forms the threat-

ening norn, but whirlwinds of dust which rise towards the cloud with a frightful giratory motion.

M. Khanikoff, a Russian traveller, describes such a phenomenon witnessed in the deserts of Kurdistan a few years ago. At the end of June, 1866, the phenomenon in question was observed near Posen, and some days later a magnificent "dust-spout" was seen in England. The spectators of the latter remarked that the column rose to the clouds, for they had the good sense to observe it as a transparency against a stormy sky. In both these cases, and in many others which it would take too long to relate here, the apparition was accompanied by terrible mechanical effects. Windmills were torn up from their bases, carts of hay were overturned, reservoirs were burst, and men and animals were struck by lightning.

Who knows that ascending and descending waterspouts are not associated in couples so as to form what is called a circuit between the sky and the earth? Indeed, at Combazon, according to M. de Gasparin, two waterspouts were seen at a certain distance from one another. And at the time of the storm at Malaunay, some singular thunder was heard in the forest of Sénart. The same mysterious correspondence exists, perhaps, between simple flashes of lightning which occur likewise at some distance from one another.

Is not this idea authorized apparently by a remark of Peltier's, on the occasion of the storm which passed over Paris on the 9th September? Not only did the illustrious physicist observe two parallel streaks of lightning which rose from the earth and forced their way to the clouds, but the thunder was heard at the same time in peals of extraordinary duration, analogous, perhaps, to the hoarse noise which accompanies waterspouts. One of these peals that was heard at Paris lasted no less than twenty minutes. The secretary of the Acade-

my learnt with surprise, a few days later, that a certain M. Charié had heard a similar rolling peal in the department de la Nièvre!

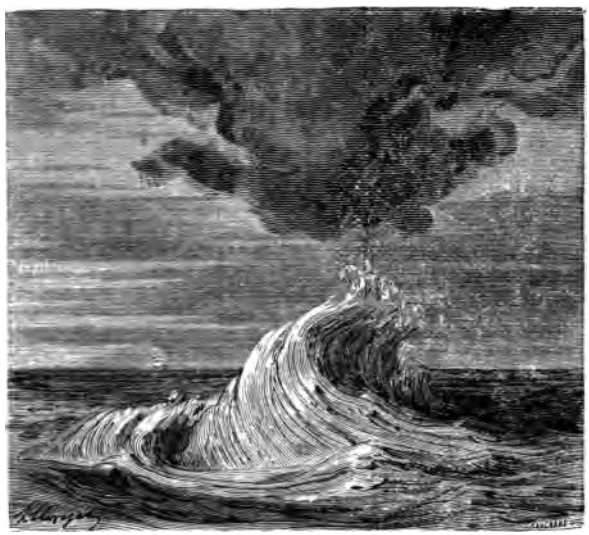
Permit us to observe that the correspondence of which we speak is probably not an idle dream. For it has been observed between the aurora borcalis and the aurora australis. We know at present that the lights which poetize the heaven of the Great Bear call up others which decorate the Southern Cross. Here then we have lightning which spreads at the same instant over our entire sphere. Why, therefore, should not other lightning spread over a vast canton, or even over an entire empire?

XIII.

LIGHTNING ON THE OCEAN.

THE storm of Chatenay stopped at a pond where its fury seemed to exhaust itself, for from this moment its motion entirely lost all vivacity. The lightning which accompanied it languished. All the fish in the pond were killed, and hundreds of trees lying side by side bore testimony to the force of the tempest. On seeing the fury of this waterspout unchained upon a contemptuous pool, how can we help perceiving that water plays a great part in these marvellous phenomena? The great facility with which it lends itself to all the caprices of the imponderables must engage, as it were, the electric whirlwinds to precipitate themselves upon the seas, and to sport with the waves.

We often see a vaporous point emerge from the clouds and progress towards the troubled surface of the waters, as the point of a compass needle directs itself towards the pole. Sometimes this incipient column



Formation of a Marine Waterspout.

stops short on its way; it is, if we may be allowed the expression, a waterspout which has missed its destination. When the column approaches to within a certain distance of the water, it is rare that the waves do not protrude in their turn, in spite of gravitation, and give rise to a protuberance or swelling on the surface of the sea. I can only compare these curious excrescences to those which are observed when the fluid from an electric machine is brought, by means of a metallic point, over a copper vessel full of water.

Sometimes the electric affinities are so powerful that one sees an immense tube lower itself to the sea without quitting the clouds. The cylindrical cloud which Captain Lebrun observed in 1806, was little less than a

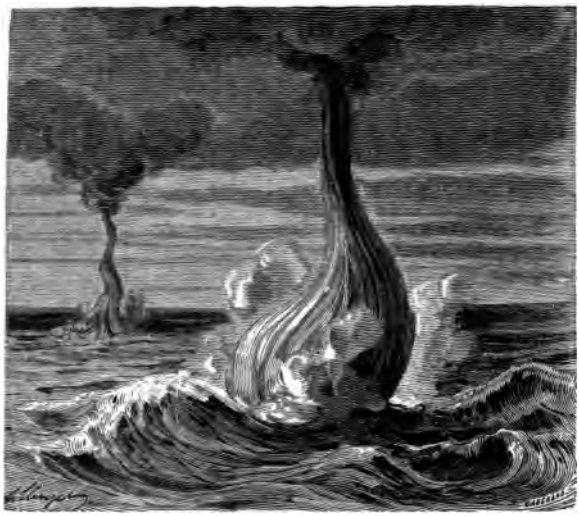
mile in length. Sometimes these fearful columns, their feet in the ocean, their head in the clouds, are formed over sheets of water of limited extent.

M. Jalabert saw the same phenomenon very distinctly in the year 1741, on the borders of the Lake of Geneva. This little inland sea, surrounded by immense mountains, is not exempt, as we may easily conceive, from any of the effects of electricity. M. Jalabert relates that he saw the wave boiling furiously, and apparently inclined to shoot up into the air in spite of the laws of gravity. Strange spectacle, and the more strange still when we observe that at a few yards' distance the air was perfectly calm! At three hundred paces from the incipient column, nothing troubled the repose of the atmosphere.

A year later the same observer again saw a well-defined, straight, menacing column emerge from the lake. No cloud formed its head, nor helped it to rise into the air. It advanced proudly, impelled by invisible attractions. Perhaps the want of a roof was prejudicial to the solidity of the strange edifice, for it was seen to disappear before it reached the shore, towards which it rushed furiously.

Many waterspouts are stronger than this. Thus, Peltier himself saw one dash impetuously against the shores of the lake, and inundate them with the water that it had carried along.

On the 17th of May, 1773, the learned traveller, Forster, saw the sea bubbling and foaming suddenly, at some distance from the ship, on board of which he was acting as observer. The expedition, commanded by Captain Cook, was then in the Straits of Princess Charlotte, a species of gulf, or arm of the sea, much wider and deeper than the port of Brest, and situated at the north-east point of the South Island of New Zealand. Soon this white foam swelled up, and the sailors on



Waterspouts.

board the *Resolution* saw emerging a little column of water, which immediately formed the basis of the water-spout. The latter, attracted by the marvellous affinity of the clouds, soon joined them. But even this union did not appear to satisfy the enormous electrical affinities called into action in this magnificent phenomenon. Three other columns, of much greater dimensions, formed themselves almost instantaneously around the first. The principal one was half a mile, at most, from the ship. It rapidly took various fantastic forms and dimensions, reminding one of the tales in the "ArabianNights."

Forster, a serious writer, little given to enthusiasm, pretends that the diameter of this terrible column of water was at least three or four hundred feet. Vio-

lently agitated by unknown forces, the liquid which formed it rose, by an incomprehensible mechanism, in tumultuous vapours, and the sunshine soon lit it up with lugubrious yellow tints.

On approaching nearer to this object, in many respects so alarming, it was soon perceived to be composed of two reversed cones, with their points opposite to each other, and united by a narrow strip about a foot broad. At the same time a torrent of salt water ascended it, in a strange kind of spiral course,—marvellous Archimedean screw extemporized amidst this frightful disorder! Oh, electricity! is this not one of thy own features? Do we not recognise thee by these marvels, which thou alone, apparently, canst teach us to admire?

The interior of this strange column was entirely hollow. We will leave it to others to explain how it happens that water, whose molecules are always ready to cede to the slightest pressure, can acquire so enormous a resistance under the influence of an agent which reduces the rocks to dust!

Peltier, in his "Traité des Trombes," has collected no less than 137 distinct and authentic observations of these phenomena; he had them from sailors and men whose good faith cannot be doubted. At each page of this curious work, the electric origin of waterspouts is manifest, and in almost every case cited a glimpse of electricity is caught.

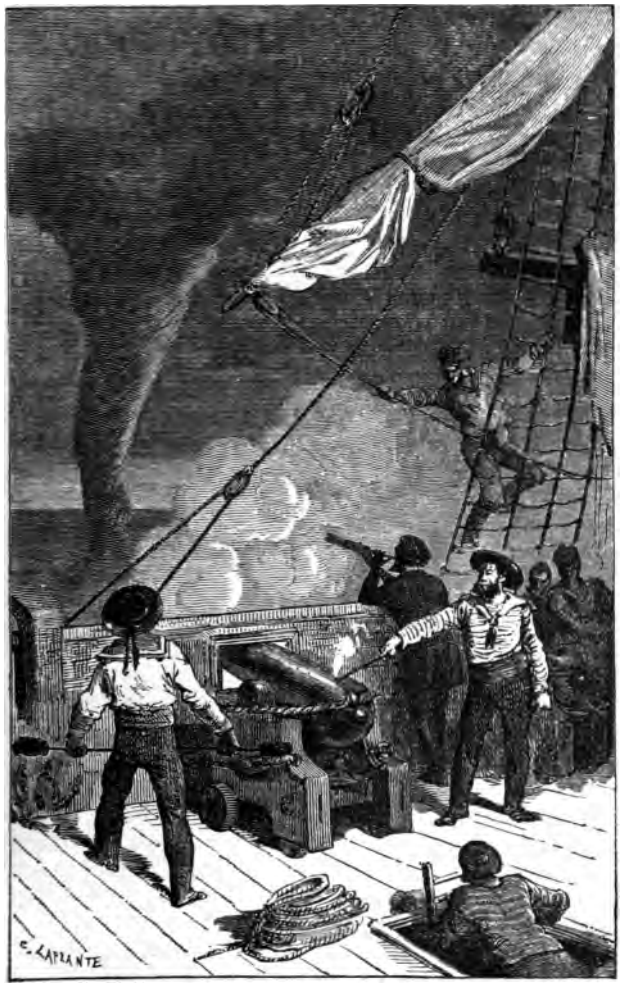
The accessory details, even the most minute, bear what we might term the seal and mark of this marvellous fluid, of this Proteus, which can take so many forms that we may fairly say it is never twice the same. Sometimes the waves produce a whistling noise, so shrill that it wounds the ear; at others, it is a hoarse rumbling, the sound of which crushes us by its depth; sometimes again, a dull roaring accompanies clouds of

dust, and these clouds of dust fraternize with the lofty nimbus, though their feet do not quit the surface of the earth.

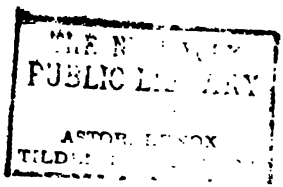
One day whilst sailing at the mouth of the river Gambia, Dr. Leymerie saw a column of light rise from the sea, spreading around a spurious phosphorescence, and his ship, *Le Vautour*, appeared to leave upon the river a luminous track!

Ten years afterwards, almost day for day, Captain Napier perceived a waterspout at three knots' length from his vessel. The sea was in ebullition, the water rose in waves as if it were gliding over the boards of a waterwheel revolving on its axis with a velocity greater than that of any of our machines. All this time the terrible meteor waltzed round with a marvellous rapidity. Heavens! whilst whirling round upon itself it suddenly approaches the ship!

Captain Napier has a sudden inspiration. . . . He remembers that he has a cannon on board. He loads, points, and fires. The waterspout appears to hesitate. The daring captain loads again. This time the ball hits precisely the thinnest portion of the cone, the long neck which unites the waves and the clouds. Victory! its cohesion is destroyed; the mass is broken into two portions, which float away at hazard. They appear like the two halves of a vast serpent striving to join themselves together again. . . . They actually succeed in doing so after several alarming attempts. . . . But the charm has disappeared: the prodigious black cloud, which almost entirely shut out the light of day, is resolved into a deluge of rain!



Sailors Firing at a Waterspout. 83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XIV.

LIGHTNING SPIRALS.

DURING the storm which burst over Paris on the 8th of April, 1866, we observed a very remarkable phenomenon, which would have escaped us altogether but for certain peculiar circumstances.

Amongst other places the lightning fell in the court-yard of a house situated at the back of the cemetery of Montmartre. The meteor descended to the earth, taking in its course, as usually happens, the pipe which discharges the rain-water from the roof; but by a fortunate coincidence this metallic tube did not communicate directly with the ground. It led to a reservoir constructed of sheet-iron about three-quarters of an inch thick.

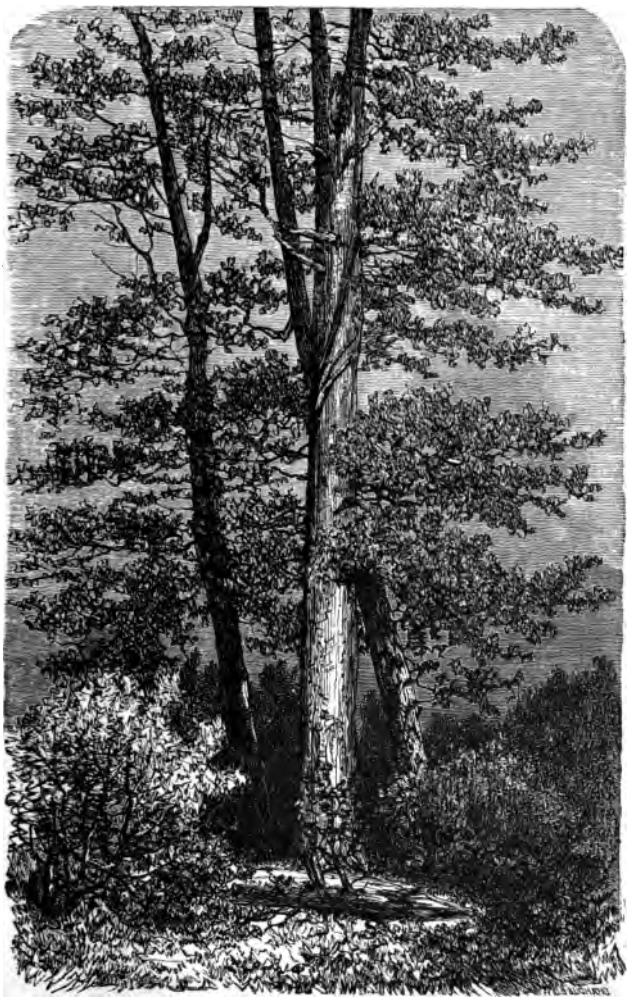
In passing into this receptacle the lightning produced certain phenomena of torsion, which appear inexplicable unless we admit that the electric matter itself is endowed with a violent rotatory motion. It might be said, indeed, on inspecting the drawing which we have had executed from nature, that the metallic vessel had been twisted, and that the spiral form had been impressed upon the metal by a giant with fiery fingers. The bars themselves, which attached the tank to the wall, had been loosened in a strange manner and turned over, some to the right, some to the left.

This circumstance having attracted our attention, we made some researches on the subject in the woods around Paris, and we sought to discover in other places traces of torsion attributable to the acting lightning.

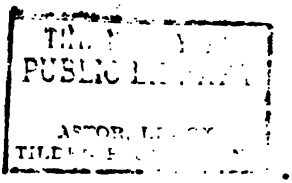
We were soon able to convince ourselves that this phenomenon is by no means rare, though we do not find it

Tank struck by Lightning at Montmartre (1866).

mentioned in our classical authors. In fact, in the forest of St. Germain, near the *Etoile du grand Veneur*,



Tree scarified by Lightning in the forest of St. Germain.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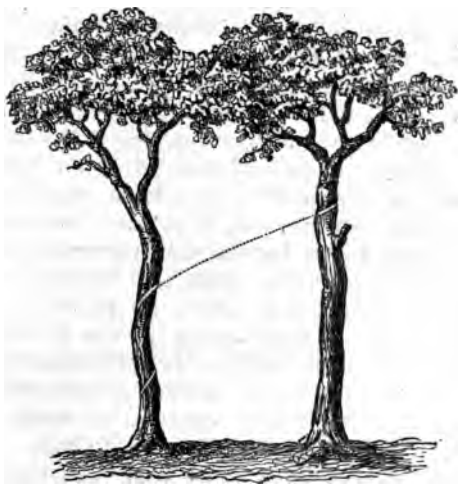
we met with an oak-tree, which we have had sketched. As will be seen by the accompanying engraving, the lightning has here again described a completely spiral figure. Every one will recognise that this tract is identical in form to that on the iron tank at Montmartre. Moreover the tree itself appears to have been energetically twisted. Is it the action of the lightning which



Lightning passing from one Tree to another.

gave the tree this spiral direction? Or was it the originally spiral direction of the fibres which caused the electricity to take this course? This is, of course, difficult to verify in a very precise manner.

We lean towards the first explanation, for we noticed in the same forest another tree struck by lightning a long time ago, which presented a similar appearance. It had, in fact, a superficial furrow, which appeared to

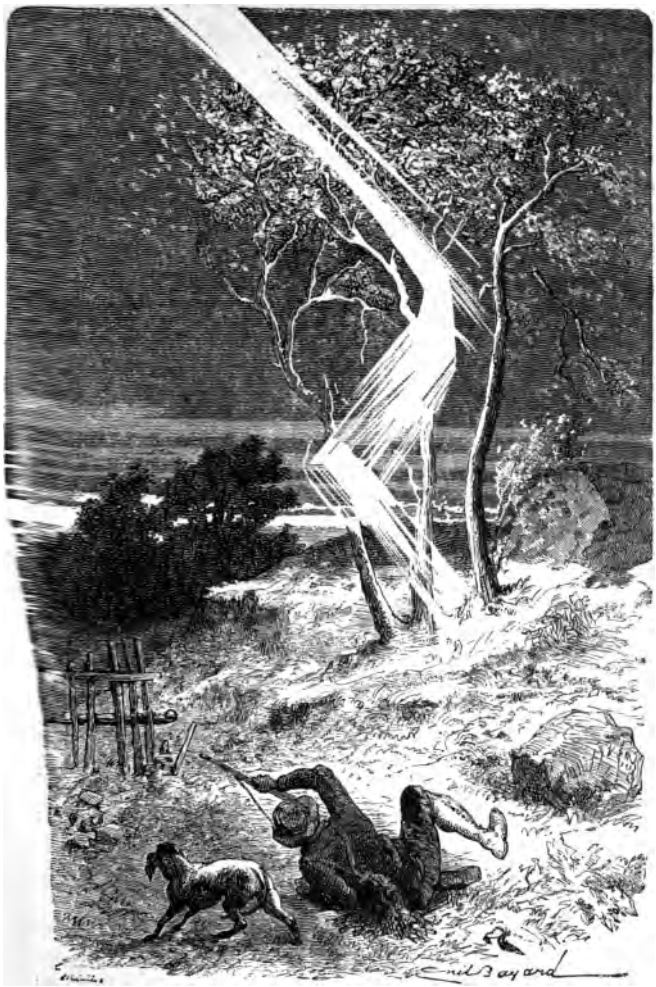
have grown straighter, but was evidently of a spiral form originally.

Foresters know that in mountainous districts wood with tortuous fibres is common enough. This effect, contrary to the ordinary laws of vegetation, is generally attributed to the action of the wind. Is it not, perhaps, simpler to look upon it as the effect of motion induced by the electric fluid, which strikes whilst whirling round like waterspouts and cyclones?

We have found in that inexhaustible mine Poggendorf's *Annalen* a fact which appears to demonstrate how energetic this tendency to a spiral motion is. The rotation is so well defined, so frank, that it persists even when lightning leaps suddenly from one tree to another. It is thus possible, in certain cases, to follow upon one tree the trace of a spiral which was begun upon another.

Certain observers pretend that they have actually seen the electric spiral impetuously traversing the atmosphere. M. Lançon, an artist to whom we owe several of our drawings, was struck by lightning in his younger days, and he tells us that he saw himself surrounded by a whirlwind of fire. He has endeavoured to represent the scene in which he was the principal actor, some fifteen or twenty years ago, and we easily recognise in his drawing the spiral form of the flash.

But what appears even more authentic than these particular cases, is the fact that circular spiral marks have been found upon dead bodies. The *Nautical Magazine* relates that a lighthouse keeper, struck by lightning in his sleep, had a scar in shape like an Archimedean screw, such as might have been produced by passing a red-hot poker over his body. This mark extended from the neck to the thigh, after tracing around the body a kind of belt. In another case the spiral scar was only observed upon the leg. In a third it extended from the right shoulder to the heel.



M. Langon struck by Lightning.

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The ancients appear also to have noticed this law of spiral rotation in the fire of the atmosphere. The greater portion of the lightning which Jupiter holds in his hands is represented as a bunch of spiral rays twisted several times over each other.

The mere observation of Nature should have indicated to our artists the existence of this characteristic property of lightning. In fact, when we reflect upon the nature of the zigzags which lightning describes in the air, we see that in most cases they may be considered as the profiles of luminous spirals. Do they not appear to be the distant tracings of immense and very oblique spirals seen projected upon the horizon? Far from being surprised at the foresight of the ancients, we are rather astonished that in the recent investigations of tempests the law which connects cyclones with thunder and lightning has not been recognised.

We might multiply the examples quoted above, and call to mind the descriptions which navigators and physicists give of cyclones, immense meteors which sometimes trouble the surface of the ocean. It is easy to recognise that ordinary wind does not give this impetuosity to the tumultuous waves, but that an influence, which remains to be explained by ordinary dynamical laws, summons these furious billows which come roaring from every point of the horizon, and, at each oscillation, appear capable of destroying a vessel.

Not only are these gigantic tempests animated with a frightful revolving motion; but, we might say, they execute an infernal dance on the surface of the troubled seas; for the meteor approaches waltzing from the pole of the earth, and when it does not reach our coasts it disappears behind the virgin icebergs, whose eternal whiteness no civilized being has soiled.

The electric cataracts of the heavens can alone supply the force necessary to preserve a kind of individu-

ality in these prodigious volumes of air, and to draw them along their oblique route. If any fixed law governs these frightful disturbances, it may be the magnetic influence of the earth, in presence of which the dreadful torrent of electric matter becomes a powerless stream.

The poles also influence the electricity which emanates from the whirling storms. For navigators have noticed with surprise that the direction of the motion of these revolving tempests is not the same in both hemispheres. The cyclones of the northern world follow the apparent motion of the sun whilst those of the southern hemisphere effect their rotation in a contrary direction.

But if the action of the earth upon the direction of cyclones is so powerful, it can not be less so, doubtless, upon the rotation of electric matter; and we might apply to these incandescent whirlwinds all the laws demonstrated by Ampère with his electro-dynamic spirals. Perhaps their direction would enable us to judge whether the lightning rose or fell, whether it is the sky which sends us a storm, or the earth which launches torrents of negative electricity into space.

Thus, in the one case, the direction of the spiral would be that of the sun's motion, and similar to the progression of the cyclones which disappear in the polar regions. In opposite circumstances, which must also occur, we should see the lightning turn in the direction of the tempests which progress towards the south pole. What discoveries remain to be made! How many means of connecting together phenomena which appear at first sight to be completely isolated, electric storms and the natural magnetic influence of our globe!

XV.

THE LIGHTNING'S BUDGET.

How many facts considered as being of the most extraordinary description would be recognised as exceedingly commonplace, if we had organized upon a sufficiently wide basis the meteorological police of our observatories! Globular lightning, which appears quite inexplicable, has been treated timidly by our physicists: its name dare scarcely be mentioned in our elementary works, as if it were in reality an apocryphal phenomenon, or a sport of Nature suffering from delirium. Here we have Dr. Sestier in his work *La Foudre* discussing a hundred and fifty different observations. And these, moreover, have all been collected within a period which does not exceed one hundred and fifty years, and over an extent of territory which does not embrace more than one *per cent.* of the earth's surface!

Taking for our starting-point the number of luminous globes mentioned by this author, we arrive at the inevitable conclusion that on an average one of these fulminating spheres falls every two or three days on some part of the earth.

Every two or three days, therefore, the Saint Thomases of science would have an opportunity of exclaiming "miracle!" if our journals and magazines were better informed of the events of which our sublunar world is the theatre.

But this number of apparitions of globular lightning is far from representing what really occurs in Nature. Who would dare to pretend that, in spite of the activity

and zeal with which Dr. Sestier has collected the data furnished in his work, he has been able to gather the whole of the testimony scattered through the academical proceedings, or through the various works which make mention of globular lightning? Can we admit, moreover, that all these meteors, even those which have fallen in the immediate neighbourhood of the capitals of civilization, have been witnessed by persons capable of understanding the importance of the spectacle which happened to delight or astonish them?

Alas! many centuries will yet elapse before popular instruction will be so widely spread that these magnificent phenomena may always find a competent observer either in America, England, or on the Continent? But even if it were so, would not the beams of the setting sun suffice to eclipse an infinity of marvellous apparitions? All the instruction in the world could not prevail against the impossibility of seeing every wonderful thing which occurs around us on this globe.

Happily for us, Nature conceals, more or less, the blows which she strikes, so that no person can account exactly for the precise degree of danger which he incurs. Let us suppose, for instance, that all the storms which happen in the course of a year were united into a single tempest. We should be perfectly stupified with fright when we saw the storm lasting four-and-twenty hours, during a whole day and a whole night. The entire country from Dunkirk to Perpignan, from Strasburg to Cape Finisterre, would be covered by a thick cloud, from which flashes of lightning and peals of thunder would uninterruptedly emanate.

Vainly would the statistics of Arago and M. Baudin then appear to prove that lightning does not strike down more than seventy or eighty of our citizens. The return of such a fearful night would be looked upon with terror by everybody; all would experience, more

or less, the feelings of the Athenians on the anniversary of the fatal night in which the ship with the black sails carried off the victims of the Minotaurus,

"Semibovumque virum, semivirumque bovem!"

Certainly the number of seventy or eighty victims is not very alarming when we compare it to the million of souls which France sends yearly beyond the grave. But it acquires quite a different signification, if it be remembered that we suppose all these accidents to occur in one day, though in reality they are disseminated in little fragments throughout the year, for Nature sends us thunder in small doses. Whilst the storm rages we may assert that the statistics are wrong. In these rare moments it is certain that lightning becomes a most active cause of death! In fact, if it smote as constantly with the same energy for the four-and-twenty hours which are allowed annually for the total duration of its saturnalia, it would slay an army of about thirty thousand men!

Whatever certain optimists may say, then, the risk of death by lightning is in reality greater than that upon our railways! Nevertheless, the latter has been made the object of special insurances which, from certain points of view, may have been successful!

But the risk of death is not the only one which men endeavour to guarantee themselves against. Almost always their goods are more precious to them than their mere existence, for, in order to preserve or to increase their wealth, they do not hesitate to compromise their health or to expose their very lives. Now it is certain that the losses experienced by the insurance companies of France amount to no less than one million pounds sterling. It results from this that, in spite of the *sublime invention of* Franklin, lightning costs us *more money than we spend* every year in teaching our

poor children to read, to write, and to count! In a word, we say it not without a profound feeling of sadness, seventy years after a glorious revolution which had for its object the good of the people, one hundred years after the invention of lightning-conductors, the civil list of lightning is superior to that of our primary instruction!

But this is not all. Sometimes lightning has caused fires which have appeared inexplicable, for no one happened to see the brilliant flash, and the voice of the thunder was not loud enough to strike the inattentive ears of the people in the neighbourhood. More than once public justice prosecutes, perhaps wrongfully, as incendaries, unlucky vagabonds and beggars who believe they have a right to curse the destiny which ofttimes they have brought upon themselves.

If our imperfect justice is liable to condemn innocent persons, have we the right to wash our hands of it? Without doubt, up to a certain point, if we had made serious efforts to utilize the sublime invention of Franklin. But, alas! how we have dishonoured the bill of exchange drawn upon us by our predecessors when they made us inheritors of this admirable discovery!

XVI.

NATURAL LIGHTNING-CONDUCTORS.

THE very important part which atmospheric electricity plays in nature has always impressed observers worthy of investigating its mysteries. Every philosopher who has penetrated farther than ordinary people into the study of the world's economy has understood that a subtle fire was necessary to purify an atmosphere rendered foul by an infinity of *miasma* of every de-

Electrified Tree.

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scription. But if thunder peals to purify the air, lightning must fall somewhere. Nature's forces cannot occupy themselves about what may happen to each of us in particular; it is our duty to investigate their laws and to profit by them accordingly. As the fire of the skies must fall upon a surface covered with men, animals, and combustible substances, of all kinds, we must open to it the road we wish it to travel.

But before tracing the plans of the new roads for the fluid, it will be wise not to close those which Nature has prepared for it, with which we cannot compete, however energetic our efforts to do so. In spite of our civilized pride, we must admit that our woodsmen have done harm which our engineers are evidently not able to repair, even if they tried. Notwithstanding the number of lightning-conductors which, based upon the immortal principles of Franklin, bristle over every department of the French empire, the sky and the earth have distanced themselves, as it were, far more than we can now reunite them. The electric communications are rarer and more difficult between these two reservoirs than in the time of the Druids (who never dreamt of lightning-conductors), when immense forests covered the soil of Europe.

The number of unfortunate individuals who have been struck by lightning whilst standing under a tree, in a forest or in a garden, furnishes us with a lesson well worthy of fixing our attention.

No! those who feel the presence of a soothing electricity which embalms the air will never say that all was ridiculous and chimerical in the opinion of the Pagans, who attributed a protecting influence to the Dryades, friends of men! The trunks of poplars and oaks may be more or less dangerous when some mysterious cause arouses streaks of fire in the invisible air, and *it will be wise to fly* from their shelter. But how

much silent thunder, how much invisible lightning filters itself through those charming branches covered with graceful leaves!

Trees of our forests, you protect more efficaciously than their presumptuous iron rods, the fortunes and lives of the fools who despise you! You save us from the destructive hailstones, as Messrs. Becquerel, father and son, have proved by their learned works. You cause the formation of that unknown principle which appears to carry with it health and life everywhere. Whence comes, indeed, that perfumed fragrance of the woods where flowers are mostly rare? What is it that, under their shades, awakens in our hearts such sweet confidence in the future? Is it not those verdant plumes of which impatient cupidity wishes to deprive our beautiful France? These emerald leaves which wave tranquilly in the air, radiate peace, harmony, and love. They pour torrents of invisible vapour into the depths of the aërial ocean, which they perfume and purify. See that oak, that elm, which subtracts lightning by each of its branches; does the fairy light not teach us the use to which the tree has been destined in the general economy of nature?

Arago understood that the frequency of hail in cultivated districts indicated a trouble produced by man, and that man ought consequently to repair his error. Struck by the increasing amount of devastation produced by the terrible hailstones upon vegetation at the period when buds burst forth, the learned author of the *Notice sur le Tonnerre* proposed to draw electricity from the clouds by means of captive balloons floating in the midst of the air and armed with an iron point. A copper wire woven into the cord which held them to the ground would conduct to the earth the fire torn from the stormy clouds. Deprived of this electric matter, of this implicit fire, the tumultuous masses would cease to

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elaborate those fearful hailstones which affright the husbandman.

But physical principles show that each of these balloons would scarcely protect, efficaciously, more than a thousand square yards of land. Even supposing that its vain cord extended *five or six hundred yards* into the air, its sphere of action would only comprise an imperceptible province lost upon the immense surface of France, though France itself is only a small corner quite lost on the immense surface of the earth. What ministerial budget could afford the expense necessary for the establishment of hail-preservers enough to protect the 203,736 square miles composing our territory? What a cost it would be to repair the envelopes to re-supply the gas which permeates constantly through these envelopes! Moreover would not these balloons, blown down towards the ground by the raging tempest, become useless at the very moment their services were most required?

To struggle victoriously against Nature, which evidently it is necessary for us to do, we must employ Nature herself: we must employ against these forces, which act of their own accord, other forces which also act by themselves?

Lightning-conductors, excellent indeed for the protection of certain chosen points such as a capital, crowded with people, monuments, and combustible matters, become perfectly useless when we wish to protect an entire country from hail, *i. e.* from the consequences of the devastations committed by a series of ignorant generations.

If we are not tired of seeing our farmers ruined by fearful storms, if we do not shrink from the example set before us by our predecessors who have robbed the earth, let us carry the axe into the forests that yet remain to us. But if history has made us wiser, let our

cupidity respect the coppices which still exist! Still more, let us endeavour to distribute them systematically over every portion of our territory, so that it would be superfluous to establish Arago's hail-preservers, even should they be admitted to be as efficacious as this philosopher believed when he proposed to give them to his country.

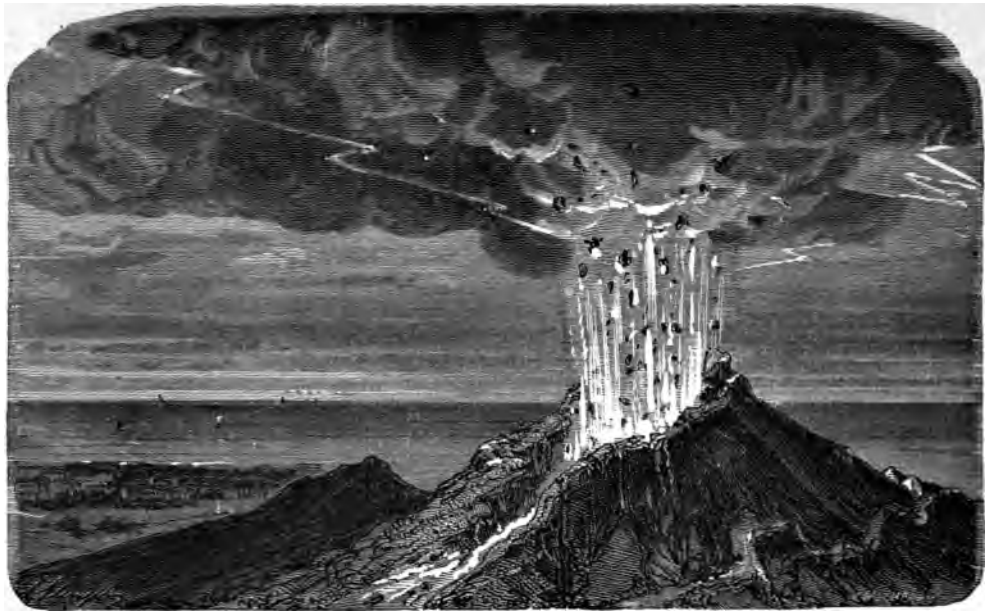
XVII.

STORMS AND EARTHQUAKES.

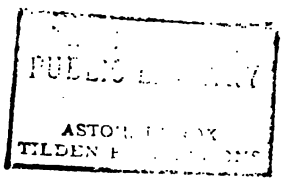
It is impossible to peruse the annals of the Vesuvian observatory without becoming convinced that electricity has also its influence in volcanic eruptions. In fact, it never neglects an opportunity of mixing itself up with everything, and whenever the lava causes its dull rumbling to be heard we may feel assured that thunder will join its voice in the sinister concert. It will speak as it did during the catastrophe which erased Herculaneum and Pompeii from the surface of the earth.

We do not think that the accompanying engraving is sufficient to give an idea of the splendour which these continual lightning flashes add to great volcanic eruptions, for these majestic phenomena surpass all description. Should it only aid slightly, however, to show the grandeur of these double storms, our artist, we feel sure, will not regret his efforts!

The floating column which emerges from volcanic craters rises high enough to carry a rash challenge to the very regions where lightning is elaborated. Every volcanic commotion of any extent is accompanied by the emission of vapour mixed with acid and sulphureous gases. It is only during slight commotions, such as that which occurred on the 14th of September, 1866,



Lightning above a Volcano.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scarcely sufficient to shake a district only a third as large as France, that the magnetic needle does not appear to be affected. Thus the columns of vapour and smoke which seem to bear aloft all the darkness of the earth, are always crowned by livid flashes of lightning. Electric radiations always struggle there with the reddish glare from the base of the infernal column.

But it is not only above volcanic cavities that the terrible voice of the thunder is heard. Indeed, when the ground is shaken, as it was in Calabria some years ago, it is also a consequence of the eternal struggle between Neptune and Pluto, the two divinities who may, almost exclusively, divide between themselves the honour of having sculptured our world into its present form. In this case, invisible vapours emerge from all the rents of the soil, carry up to the clouds the news of the great shock, and thus prepare fresh storms. Most frequently, abundant and deluging rain, produced by these extraordinary evaporations, adds new trials to those already experienced by the inhabitants of these desolated districts. The rain is almost always escorted by thunder and lightning, which frightens oftener than it strikes, but which is soon believed to be the expression of celestial maledictions.

The furious tempests which overturn our buildings have, also, more frequently than might be imagined, an echo in the deep regions of the earth. In fact, we cannot help remarking that great atmospherical commotions are accompanied by a change in the supply and in the temperature of the water of Artesian wells. We will discuss later the lessons furnished by these liquid soundings; but can we avoid calling attention to the danger revealed to us by their means? In a thousand places, doubtless, the crust of the earth, solidified with so much difficulty by the work of centuries, only demands a pretext to give birth to some new crater.

Is it uselessly that cyclones carry to the poles vapour collected in the regions of the tropics, which, during its entire course, puts into communication the two electricities of the earth? The substance of a thousand thunderstorms is annihilated every instant whilst this meteor describes its immense circles. Is this without danger for the equilibrium established below in the deep regions of the earth? Who dares to say what would become of our empires, of our proud civilization, the day that the storm above shall really coalesce with that which growls in the hidden regions—when the thunder and lightning will conspire with the waves of the ignivomous ocean itself?

We do not touch upon this subject without some apprehension, but it seems impossible not to make an effort to show how far we may logically extend the sublime concatenation of all the grand phenomena of nature.

All the parts of the earth, as a thousand phenomena prove, react constantly one upon the other, by means of a fluid analogous to that which accompanies our movements and our sensations. It would seem, then, that one of the functions of electricity is to connect, in a marvellous fashion, the different members of organisms which, without it, would be nothing more than inert bodies. Its wonderful function is the same whether the organism be that of an ant, a man, or a globe revolving in its orbit through celestial space.

XVIII.

THE VOICE OF THE THUNDER.

In spite of all the conquests of critical Philosophy, we cannot forget that thunder is a manifestation of the

unknown forces which govern the world. When it causes its powerful voice to be heard, we feel as if our pride should bend its head. How can we forget, indeed, when we hear the sound of this celestial music, the mightiness of the hidden causes in the midst of which we pass our troubled and ephemeral existence! How great would our emotion be, if we had preserved in our minds all the superstitions of another age; if, credulous and superstitious as an adorer of idols must have been, we found ourselves suddenly enveloped in flames! Would it require more, asks with much reason the pious Meander in his *Commentaries of the Acts of the Apostles*, for any Saul of Ephesus, hardened by crime, heated in persecution, to rise transformed into a St. Paul, improvised Christian hero, thirsting for martyrdom?

Perhaps the amiable Leo X., or the learned Erasmus, would have been able to prevent, or at least to have delayed, the divorce of the Church, had it not been for the thunderbolt which fell near Luther and killed before his eyes, a friend whose piety was somewhat doubtful. Upon how little depend the destinies of religions and empires! will exclaim those who believe in minor causes. The Roman Catholic world would have had a fine chance of preserving its integrity for a long time but for this tragical accident; for Luther himself takes care to tell us in his *Memoirs*, that this circumstance decided him to put on the robes which he was destined a little later to throw from his restless shoulders, finding them too heavy to clothe his ancient faith, already much shaken.

We could bring forward many other examples if we desired to enter into the anecdotic path of history.

First we should see Apollonius of Tyana predicting the prophetic lightning which wrung the goblet from the impure hands of Nero. Next we should have to

relate that a glorious thunderbolt transported to the bust of Antoninus the Pious a crown belonging to the statue of Jupiter. We should not forget to mention, either, that an electric light illuminated the eastern horizon at the birth of Mahomet, for Oriental authors would furnish us with a collection of extraordinary facts far richer than those of Plutarch, and Herodotus, or of all the Roman historians.

At all events, do not let us be too ready to ridicule impressionable people who have overloaded their annals with fictions as poetical as they are really extravagant. The idea of connecting thunderbolts with events which are accomplished among men is very natural in presence of a multitude of coincidences brought about by chance; more especially in hot countries where electrical phenomena succeed each other almost without interruption. Boussingault pretends that an observer whose ear was delicate enough to take in all the thunder of the torrid zone, would listen to a continuous roll, ceasing not for a single instant either by day or night.

For many centuries poets have celebrated in magnificent terms the power and the majesty of this formidable voice which troubles successively all the echoes in the world. But no one thought of seeking for the laws which govern these grave and majestic sounds. The indiscreet philosopher who first placed his ear to the keyhole of Olympia must have been a very strange personage.

After having travelled in England, De l'Isle determined to go to Russia, a country then in a complete state of barbarism, to establish there, at the request of Peter the Great, a school of Astronomy. When he arrived at St. Petersburg, the reign of Catherine had commenced. De l'Isle, however, met with a brilliant reception, and the Empress furnished him with the

means of popularizing his favourite science. The school of St. Petersburg soon acquired a great reputation in the scientific world, and for many long years the French astronomer laboured to perfect it in every detail. When he became old, De l'Isle thought he might return to France to enjoy there his well-earned reputation. But alas! what recompense did he meet with in the ungrateful city, the tomb of so many men deserving of celebrity? A pension of 36*l.* a year and a deserted barn, the remains of the Hôtel Cluny, where he alone dared to brave the rigours of the winter nights. As passionately fond of astronomy as other men are of wealth, De' l'Isle possessed to the end of his long career a scientific ardour which neither the cold, nor age, nor even misery could extinguish; and the subject of thunder occupied him more or less, to his last moments.

A thousand examples prove that the noise of our artillery carries farther than the rolling of atmospheric discharges; in spite of his enthusiasm, De l'Isle was obliged to admit this. However, do not let us hasten to pride ourselves on this advantage. Effectively, if the cannon's voice is more penetrating, it does not produce that sonorous noise, full of majesty, one might even say full of calm! Our weakness betrays itself even in our triumphs, and is seen through the transparency of our sham majesty.

The unknown powers of nature love to distract us, to alarm us by an immense rolling peal, very different from the dull rumbling noise of the waterspout. De l'Isle, astonished at the fact, relates with warmth that he has heard this species of supreme chant vibrate in his ears for the space of a whole minute!

How can we explain that a single shock can produce a rumbling so singularly prolonged when we know that this shock *itself does not* occupy the thousandth part *of a second?*

The higher regions of the atmosph re contain a quantity of watery vapour which, thoi gh extremely variable according to the seasons of the year, is always considerable. How many phenomena must, therefore, be forcibly produced under the influence of the enormous quantity of heat which the electric spark develops all along its course!

Is it necessary to state that the elastic force of this vapour so suddenly heated must increase with frightful rapidity, and decrease with no less velocity?

Hence a double shock, oscillations, and consequently a centre of vibration susceptible of producing a multitude of sonorous waves.

But the electric spark of nature possesses all the properties of the spark of our common voltaic batteries, which not only produces a great quantity of heat, but reduces to its gaseous elements the aqueous vapour which it heats.

Now this ultimate decomposition cannot be produced instantaneously without being accompanied by an explosion comparable to that of gunpowder or meal-powder.

Each point in the vortex of flame which, like an immense chain, joins nimbus clouds with the earth, is the theatre of individual explosions. The gunpowder of the aërial mine ignites itself like a fearful fuse many miles long.

All these explosions occur at the same physical instant, so rapid is electricity; indeed their light produces to our eyes a single sensation.

But if light only takes eight minutes to travel to us from the sun, the sound of our voice would require ninety days to travel the same distance; for the lazy and negligent vibrations of sound progress scarcely a hundred times quicker than a railway train at full speed.

Take care if the noise is heard at the same time that the light is seen; the storm is then hovering over our heads! For every distance of about 328 yards one second of time is required between the flash and the thunder. If the rolling peal lasts for whole minutes at a time, the luminous arc is immense, and the points which are nearest to us are separated from its further extremity by many miles of explosion of flame.

However, we must not fancy that this estimate of the length of a lightning flash is susceptible of very great precision. The noise of the thunder is often pro'onged by terrestrial echoes; and it is in the deep ravines of mountains that one should hear the rolling peal, echoed from the sides of the rocks. Even on the plains we should be liable to error, not only on account of the earth, but from the fact that the lower surface of the clouds themselves often reflects the sound with singular energy. We can rely upon nothing, therefore, but direct measurement, which might be effected by means of photography.

For the chemical action of light is as rapid as that of the subtle electric spark which shows us the cannon-ball motionless in the air.

XIX.

LIGHTNING AND THE CHOLERA.

Two or three years ago the question of spontaneous generation was passionately discussed by naturalists, and the Academy of Paris resolved to undertake a decisive experiment. Some expert chemist prepared a great number of *glass globes, all* of the same size, all provi*ded with a tube of the* same form, and each containing

the same quantity of a decoction of yeast. Some were filled with the air of the great amphitheatre of La Sorbonne, and almost all of these proved the correctness of M. Pasteur's views; but the others had been transported to Bellevue, and, placed under graceful foliage, filled with electrified air rich in ozone. The decoction of yeast in the latter did not remain inert. It might have been said that germs without number had penetrated into their interiors, for life was awakened in them with surprising activity. Almost all were filled with vegetations and animalcules, whose organizations placed them high in the ranks of infusoria. It was ozone, faithful messenger, charged with the powers of lightning, that had evidently produced these marvellous and hitherto inexplicable effects.

In fact, electricity exalts the properties of atmospheric oxygen. It excites the appetite of that which it tears from the hydrogen of water. It transforms this gaseous substance, already so active, into an agent of decomposition, and combination, acting in the same manner as the germs—who knows, perhaps into a germ itself?

Innumerable electric discharges must have accompanied the apparition of life, if it be true that it is not eternal, upon the surface of the earth. The energy of the great burning element of our sublunar world must have been driven into paroxysms by dreadful storms.

But without mounting so near to the origin of things, we may safely affirm that vegetables would not be capable of assimilating the elements of the air, did not electricity give them peculiar properties of combination. The wonderful flash manufactures before our eyes nitrates which the rain brings down to fertilize the surface of the earth. Thus electricity utilizes nitrogen, the most inert of gases!

Divine electricity, if thou takest indeed the lives of

a few animals and plants, it is not a reason for outraging thy works or an excuse for not recognising the usefulness of thy functions in Nature. How many beings owe their existence to thee? Is it not of thee we must speak, as Lucretius spoke of Venus?

After certain claps of thunder the atmospheric ozone is so abundant that its odour is sufficiently powerful to expose the lives of those who breathe it. Boyle speaks of an accident which occurred from this wonderful electrization of the air at Geneva, whilst he stayed in that town, where he had taken refuge to complete his education and to avoid the revolution in England. A sentinel nearly fell into the lake, suffocated by the sulphureous odour which accompanied a thunderbolt that fell in the neighbourhood of his guard box. It may be that he was hit also by the return stroke.

A hundred and fifty years later the same phenomenon occurred in the interior of the church of Kervern during divine service. The lightning struck no one, but the odour which it developed was so intense that almost every person present, from this or from fright, became unconscious. We need not be astonished then that the ancients noticed this property, nor that they early remarked that the odour left by lightning was of a sulphureous nature. According to their custom of generalizing all results of observation, they had concluded that sulphur itself was formed by lightning, and consequently they gave it the name of *theion*, which, in the language of Plato, signifies "divine."

We shall see presently that the ancients were far nearer the truth than is generally supposed in our days.

But we must observe that the absence of ozone in the air appears to be connected with the appearance of cholera, as if the active element kept a vigilant guard over the salubrity of the atmosphere, and disappeared when it ceased to exist.

In fact, it does not seem illogical to suppose that electrified oxygen destroys morbid germs, those floating nothings which carry death with them. What more powerful disinfectant could we have than the gas which turns the ozone test-paper blue? What chlorinated fumigation could, like that produced by thunder, spread over an entire country? Nevertheless, let us hasten to declare, cholera appears to invade great capitals even after severe storms. It is true that it has been known to disappear after other storms, so that the electric fire which brought it also caused it to disappear. Perhaps, some persons thought, it only reigned between the two thunderstorm! At all events, let not the tempest be scandalized; and only to quote one more fact, let us remind our readers that the town of Milan was freed from the famous black plague which devastated Europe in 1431, after one of those dreadful storms which, from their violence alone, penetrate and ventilate the most confined of dwellings.

XX.

WHAT IT IS THAT LIGHTNING FINDS IN THE AIR.

In the month of May 1772, the Duc de Bourbon was strolling out at Chantilly, accompanied by a numerous suite, when he was suddenly seen to be enveloped in a bright flame. On approaching the prince, the gentlemen who followed him saw, with surprise, upon his cheeks and his upper lip, greasy black spots, produced by a species of soot deposited by the lightning.

M. Babinet tells us, in the *Revue des Deux Mondes* of the 15th May, 1854, that on the highest points of rocks traces of melted metal are seen, which appear to

have been deposited there by lightning, the streaks of which are still visible.

Sometimes these black matters are abundant enough to colour the skin of the unfortunate persons struck by the electric fluid. Thus Dr. Sestier relates the story of an old man and his daughter who were found dead in their room, their faces having been completely blackened by lightning. The same author tells us in another place that the bodies of some sailors struck by lightning appeared as if they had been rolled in gunpowder, for they were covered from head to foot by a black substance.

It is easy to believe that the foregoing narratives are in no way exaggerated. The atmospheric spark being considered as an immense voltaic flash, we cannot be surprised to hear that it produces on a large scale the transportation of different matters, which we see effected precisely in the same manner in our smaller laboratory experiments.

Lightning collects and carries with it all the substances it meets, and whilst describing its long curve in the air, it deposits its load at the point where it strikes—upon a tree, a house, a peasant, or a duke—it makes no difference.

The nature of the deposit depends entirely upon that of the substances which the forked flash happens to meet with in the atmosphere.

When they picked up the body of a vine grower near Orleans, who had been struck by lightning under a tree where he had sought shelter, it was observed that his face was covered with a layer of oxide of iron.

Aërolites which circulate in the aërial ocean, and are more or less consumed in their fall to the surface of the earth, leave in the air certain matters in the state of the finest and most impalpable dust.[1] Lightning, which

[1] *Those of our readers who* are interested in this subject may compare *with the above, chapter* xii. "On Meteoric Dust," &c. of a re-

allows nothing to escape, seizes upon these atoms, and, having collected them, deposits them upon the objects which it strikes.

M. Fusinieri, the well-known Italian physicist, who made some remarkable experiments on the discharge of the Leyden jar, formerly observed that houses struck by lightning were covered, in this particular place, with a layer of sulphide of iron.

The substance is thus projected so powerfully that it penetrates into bodies in a most extraordinary manner. Who would believe that M. Fusinieri discovered sulphide of iron in the heart of poplar-trees on which lightning had fallen?

In examining the *débris* of the roof of the church of Upsal which had been struck by lightning, Bergmann perceived a powder of singular aspect, something like sulphur, but studying it more closely he convinced himself that it was copper in a very fine state of division, torn by the lightning from some roof in the neighbourhood. In this case a sheet of copper had acted like the physical apparatus called an excitor, one portion of which gives rise to a transport of metallic particles when the electric discharge is extremely intense.

Sometimes sulphur carried by lightning is deposited in great quantities; for instance, during the storm of the 24th of August, 1764. It was found that the slates on the Castle of Heidelberg were covered with little yellow bodies, and that the walls struck by lightning had been covered, in those places, by a species of varnish.

If sulphur, which is of course charged with electricity when propelled by the electric fluid, falls upon substances susceptible of combining with it, these combi-

cent volume, by Mr. Phipson, entitled "Meteors, Aërolites, and Falling Stars," also a paragraph in the Appendix of the same work, p. 229. [Translator's Note.]

nations are at once formed with an ease which will surprise no one. In fact, it is well known how ready electrified substances are to form new compounds. M. Bonjean has given, in the *Comptes rendus* of the Paris Academy, a striking example of these transformations effected in the great crucible of nature.

On the 14th of June, 1846, lightning struck the church of Saint-Thibaux-de-Cour. As often happens, the building was suddenly filled with vapour, which exhaled a strong sulphureous odour. When it was observed what had occurred, it was seen that a picture-frame and six gilt chandeliers had been instantly covered with a layer of sulphide. Chemical analysis placed beyond all doubt the nature of the product formed in so singular a manner.

There are strokes of lightning which produce a precisely contrary effect. Instead of bringing us anything, it tears away some portion of the substance from which it takes its departure.

A young lady who wore a silver necklace was treated like the roof of the church at Upsal. The lightning was not content with having ruptured the coquettish ornament, it tore away some particles from each of its tiny beads. When the poor girl was picked up, her skin was found to be marked with little black lines corresponding to each of the silver beads of her ornament. The metallic dust collected by the fluid at the distance of some tenths of an inch, had been deposited there.

A wealthy lady, who wore a massive gold chain when she was struck by lightning, was marked in the same manner, branded by a purple line formed of the particles of her chain.

These observations might have taught chemists, who however knew *it before, that* the colour of metals is *changed when they are* reduced to powder finer than *that which can be formed* by a file.

Although this property of matter may not be new to us, we cannot be the less surprised at it. For we recognise in these facts, that lightning has the power of pulverizing the elements of bodies so as to reduce them, as it seems to the state of vapour, without causing them to pass through the liquid state. Is not this the conclusion to be drawn from the fact of bell wires having been so often volatilized by the molecular action of lightning?

It is not our fault if we are obliged to torture the sense of words in order to describe phenomena which are unknown.

The atmospheric spark possesses, then, properties which are diametrically opposed to each other.

Whilst we observe lightning collecting objects widely dispersed, perhaps another flash is reducing to atoms bodies of the hardest nature. Can we wonder at it? Certainly not, since all flashes of lightning do not descend from the clouds to the earth.

If the heavens often bombard us, we may say that we have no cause to complain, for we return with interest the blows we receive.

The ancients were accustomed to look upon lightning as a truly generative power, since they observed that it brought with it substances of which they ignored the origin. They followed up their error, for, according to their commentaries, they classed aërolites as thunderbolts. But they were, perhaps, not so far from conceiving the ingenious notion of Arago; namely, that the rain sweeps the dust from the atmosphere. What a gigantic besom we have in those immense lightning flashes many leagues in length, which rush through the enormous aërial ocean in whose bosom hover so much metallic and sulphureous dust!

XXI.

MOTIVE POWER OF LIGHTNING.

ALTHOUGH the masts of ships of war are regularly looked to and attended to with very great care, it is evidently impossible to prevent some drops of moisture from slipping into the holes or cracks, which many causes produce in the interior of the most carefully-kept timber. Generally this sort of gangrene does not give rise to much inconvenience, for the harm cannot attain to a serious extent without being noticed even by the most negligent sailors. But if lightning happened to strike such a mast, the smallest atom of water imprisoned in it would act like fulminating powder! Whenever the fire of heaven finds the elements of an explosion collected together on its course, this explosion takes place with frightful energy. It appears even that, in these cases, the danger is so much the greater when the liquid mass, traversed by the electric fluid, is exceedingly small.

If the water has penetrated without difficulty to its little den by means of a wide crack, it will be shot out of this orifice in the form of steam. The effect produced by the passage of the meteor will be comparable to that of a cannon, charged with powder only. But if some atoms of liquid have filtered themselves in from molecule to molecule, by a kind of suction, things happen in a very different manner. The drops of water imprisoned in the cells of the wood, where they have introduced *themselves with* so much difficulty, burst *their envelopes as a charge* of powder explodes a bomb.

shell. It will be no longer steam, at a pressure of thirty or forty atmospheres, but a torrent of oxygen and hydrogen, at an incandescent temperature.

It was water reduced to the state of isolated gases which must have produced the effects observed on board the ship *Le Patriote*, on the night of the 11th and 12th July, 1852. The lightning struck a mast of this ship, and split it for a length of more than thirty yards. At the same time, the gaseous products evolved on the spot by the rapid passage of the electric spark, were abundant enough to scatter afar the fragments of wood. One block was cut off as neatly as if the operation had been performed by a saw; it was projected with its thicker end against a solid partition of planks, some hundred paces distant, into which it sunk so deeply, and fixed itself so tightly, that great force was required to pull it from the hole it had made. This extemporized bullet weighed, we are assured, no less than 160 lbs.

The lightning that fell on the Abbey du Val, near Ile-Adam, on the 25th June, 1756—that is, eighty-six years sooner—produced effects owing to the same cause, but of a very different nature; it struck a fine isolated oak-tree, 17½ yards high, and more than a yard in circumference at its base. Neither the trunk, the branches, nor the bark, showed the slightest sign of burning, but the entire tree was dried up, as if an enormous heat had been developed on every point of its substance. What was the cause of this phenomenon? Is it necessary to state that it was owing to the calorific power of lightning? Need this fact surprise us, when we know that electricity possesses the property of making metals red hot, and even of volatilizing them. If it was not known that water existed in all the living parts of an oak-tree, especially in the month of June, when the sap is in active motion, it would certainly have been learnt in this particular observation. For the sudden evapora-

tion of the liquid contained in the vascular system of the tree, was accompanied by an astonishing number of explosions. The branches and the trunk were slashed into a hundred thousand fragments. The vessels filled with liquid sap were ruptured, and seen wide gaping in the places they occupied, when the thunderbolt split them open.

No detail is missing in this magnificent lesson, which Nature, our sublime mistress, has taken it into her head to give us.

The young wood beneath the bark is, as we all know, saturated with moisture; its fibres were, therefore, transformed into a species of fulminating chemise. The bark, more or less impermeable, had endeavoured to resist. It had become, what persons become when they try to arrest the action of great mysterious forces,—reduced to imperceptible fragments; it had been cast far away from the trunk, and had fallen to the ground like a kind of dust.

When the sap is farther from the circumference, and the lightning happens to reach it, the explosions are much more terrible, in virtue of the principle enunciated above. The resistance which wood offers to the elastic force of vapour, may, in such a case, produce the entire destruction of the tree, as we see mentioned by Professor Munke, in Poggendorff's *Annalen*. The tree was absolutely annihilated. A few scattered fragments of its former tissue, some tenths of an inch thick, were alone seen dispersed here and there.

Sometimes the aspect of a trunk struck by lightning is very different, for cases are quoted in which the fluid has introduced itself into the very centre of the wood; the electricity has then formed a species of canal, the sides of which are blackened as if by means of a red-hot iron. A walnut-tree, centuries old, at La Fontaine-*Française, which had lost* all its branches, was perfora-

ted so regularly by a thunderbolt, that it would not have been difficult to have made its trunk into a wooden cannon, such as the Chinese use. But walnut-trees often become hollow from age.

These capricious dislocations sometimes present very fantastical appearances. A very curious case happened on the passage of a great waterspout at Monville, which occurred at a period when trees have scarcely any sap in motion in their vessels. The bark was separated from the tree in an exceedingly neat manner, so that it could be detached completely; a kind of hollow cylinder was thus obtained, the exact form of the solid cylinder which occupied its axis.

On the 25th of August, 1818, a large oak-tree, some eighty-five feet high, standing in the forest of Thury, was struck by a gigantic thunderbolt. In the course of twenty-four hours its leaves became yellow, and then fell, which indicated that the fire of heaven had produced some deep-seated wound. However, externally a slight groove was all that could be seen. Attracted by the singularity of this circumstance, a certain botanist sought to discover what had really happened; he caused the tree to be pulled down and examined it carefully. In making his *post-mortem* examination of the trunk, he perceived that it had been split throughout its entire length. The different layers, perfectly detached, adhered no longer one to the other; the tree might have been drawn out like the joints of an enormous telescope.

The effects of lightning upon inanimate bodies will furnish us with other instances, still more calculated to allow us to form some idea of the immensely powerful motive force which it develops; if the ancients had observed scientifically the numerous facts which they must have witnessed, and in which the expansive power of steam is so manifest, humanity would not have waited

until Watt or Newcomen for the production of a new motive power.

On the 6th of August, 1809, at two o'clock in the afternoon, a dreadful explosion was heard in the house of Mr. Chadwick, a gentleman living in the neighbourhood of Manchester. The external wall of a little building in brick, which was thirty-six inches wide, three and a half yards high, and had one foot of foundation, was literally uprooted, and carried over the ground, without quitting its upright position. It was found, on examining what had happened, that one extremity of the building had been moved three yards, and the other, round which the wall had turned in its movement, one yard and a quarter. The wall, thus lifted up, was composed of about 7,000 bricks, and would weigh about twenty-three tons.

This shows us that the power which the lightning must have employed did not interfere with the neatness with which it did this wonderful work. The meteor had in fact transported the wall as cleverly as American engineers move entire houses.

About a hundred years ago, lightning fell at Funzie, in the island of Fetlar, the most northern of the Shetland Isles. It struck a micaceous rock, some one hundred and five feet long, by ten feet wide, and four feet thick. In one instant, this gigantic stone was upheaved from the spot, where it had stood for so many centuries, and broken into an infinite number of fragments of every dimension. One of the latter, which was about forty feet long, seven feet wide, and four feet thick, contained at least a thousand times the quantity of matter which composed the block detached from the foremast of the *Patriote*. It was thrown to such a distance that it fell into the sea, about a hundred yards from the place. *Another fragment*, weighing about fifty-four *tons, was transported to* half the distance. To arrive

at this point, after describing a parabola in the air, lightning must have employed upon it an enormous motive power. But independently of this supposition, the water confined in the stone must have produced an explosive action truly marvellous.

The *Mining Journal* informs us that in England eight ounces of blasting powder are required to detach a rock weighing one ton. According, therefore, to the figures above quoted, the rock at Fetlar must have required, at least, 160 lbs. of powder to break it down, so as to be carried away by the workmen. How would it have been to have thrown it to so great a distance? We shall not, then, be accused of exaggeration, when we state that it would be impossible to give a second representation of this explosion, even if we used 200 lbs. of ordinary blasting powder.

Let us not be surprised, then, on learning that some clever engineers have thought of utilizing the formidable power which resides in the thunderbolt, such as falls upon ordinary occasions. In fact, Dr. Sestier tells us, that some Scotchmen wishing to get rid of an isolated mass of rock, planted an enormous bar of iron upon it. The lightning, thus provoked, was not long in replying to the challenge. The rock was split to pieces, and there was no longer any difficulty in carting away the fragments, which were probably used for building. Do we deceive ourselves, when we imagine that this example is not destined to remain long isolated in the annals of science? Who knows but what the day may come, when it will be taught in our schools how to apply lightning to the wants of industry, medicine, hygiene, &c.? To protect oneself from the noxious actions of nature's forces, is the first step of scientific wisdom; should it not be, also, that of our Academies and Royal Societies? Lightning will never be tamed by future generations, until men shall have become intelligent

enough to make it subservient in some manner to their arts. It is probable, nevertheless, that it would never be a motive power of great constancy.

XXII.

FOSSIL LIGHTNING.

ARAGO, by comparing a great number of observations, has demonstrated that thunder and lightning are much rarer on the open sea than on the continents. It is, effectively, the land which may be considered as the principal disturbing influence acting upon the equilibrium of climates and temperatures. It is the land which gets heated and cooled, whilst the vapour emitted by the ocean keeps the surface of the seas in a relatively uniform state. Again, on the other hand, we may affirm that the land acts energetically for the actual conservation of the world. In fact, without the summits of the mountains, those marvellous lightning conductors, electricity would accumulate indefinitely in the higher regions without finding any issue, and there would come a moment of paroxysm in which the atmosphere would become powerless, and, so to say, would be broken to atoms.

Is it not far from the coasts, on the wide ocean, that cyclones are formed—feeble image, doubtless, of what electric tempests would be if plutonic action had not uplifted, from the depths of the ocean itself, protecting cones of rock?

May we not admire the sublime parsimony of nature which causes so many contrary elements and so many forces to fulfil the same object? The revolutions of the air, and those of the lower regions of the globe, do they not seem appointed to maintain that stability of

things which is necessary for the production of life, for the evolution of thought, and to cause the earth to become a sort of theatre for virtue, and an object of interesting scientific research? However, up to the present time, geologists have often confounded traces of fulguration with the effects of simple volcanic eruption. They have almost always neglected to study these honourable scars. Where is the natural philospher who will understand that he can cover himself with immortal glory, by studying lightning tracks, which are doubtless easier seen than the direction of striated rocks? Has not the action of the celestial fire been as energetic on the summits of the Pyrenees or the Alps as the simple friction of erratic boulders? Who will dare to assert that the earth has not passed through a *lightning period*, as it has traversed what is called the *glacial epoch?*

Must not Jupiter have ofttimes interfered in the battles which Neptune and Vulcan have fought with each other?

Let us hasten to do homage to certain thinkers, and to exclude from our criticism the researches made by De Saussure on Mont Blanc, by Roman on the Pic du Midi, by Humboldt and Bonpland on the high ridges of Toluca. Everywhere the traces of the action of lightning resemble a species of enamel, containing an infinite number of little vesicles. Behind this varnish we see by transparency the marks of numerous streaks which the lightning has covered with a thin coating, showing their different tints. The thickness of this vitrification is very slight, its surface is scarcely more than a few square inches large; it seems as if the electric fluid had rather caressed the rocks than shaken them.

But in sandy plains we notice more decided traces, which have struck other eyes besides those of the above illustrious observers.

Lucan draws us a poetical picture of the tubes formed by lightning in sandy places.

Here is the description which he gives us of the mound of earth, humble rustic tomb, beneath which reposes the great Pompey, the illustrious victim of Cæsar, with whom fell Roman liberty:—

"For who but shall prefer thy tomb above
The meaner fane of an Egyptian Jove?
Nor envy thou if abject Romans raise
Statues and temples to their tyrant's praise;
Though his proud name on altars may preside,
And thine be washed by every rolling tide;
Thy grave shall the vain pageantry despise—
Thy grave where that great god, thy fortune lies.
E'en those who kneel not to the gods above,
Nor offer sacrifice or prayer to Jove,
To the Bidental bend their humble eyes,
And worship where the buried thunder lies."

XXIII.

THE "PHARSALIA" AND LIGHTNING.

AMONG the poets of antiquity, Lucan is, incontestably, the one who has given the best descriptions of lightning. We have often been impressed, whilst reading the works of this author (so ill-treated by passionate critics), by the profound sentiment of nature which breathes in every verse of the *Pharsalia*.

We may perhaps be allowed to show with what facility Lucan has described different electrical phenomena, with what delicacy he has painted them in a work which human passions cannot prevent from lasting eternally, that is to say, as long as there exists upon earth men who are worthy of *admiring* beauties which are really *eternal*.

Cæsar is desirous of pursuing his success—his impious attempt against the liberty of the people and the senate. He must have no enemies behind him; he must overcome the resistance of the Massilians, who, in spite of the doctrines and habits of the Greeks, have remained faithful to misfortune. The justness of the cause defended by Pompey had seduced these inconstant Phocians themselves. What more eloquent homage could we conceive?

A virgin forest covers the heights which command the great city. Cæsar respects it not. Its trees groan under the axe of his legions: but the sighs of the nymphs cannot stop the man who has trodden under foot the laws of his native country. Then it seems as if nature would take the side of Pompey. The trees appear to lend their aid; although separated from the roots they still stand erect, terrible and menacing. But it is not yet enough, the soldiers continue their work. Then lights are seen to rise, produced by the hidden forces of the earth. Castor and Pollux, the fire of St. Elmo, appears on the branches, and the poet exclaims :—

"With sparkling flames the trees unburning shine!"

Soon, a deluge of rain falls, which puts the legions to flight:

"Catching and driving with the wind it grows,
Fierce through the shade the burning deluge glows."

It is the fury of Nature's elements which interferes with the punishment of men. The mixed water and fire weaken each other.

Lucan describes with no less talent the tempest which overtakes Cæsar in the famous ship to which he has confided his fortunes. A fearful waterspout occurs. It is about to swallow up the future master of the world!

Who knows if there will ever be another Cæsar capable of founding another empire? Commodus, Nero, Domitian, Tiberius, are, perhaps, about to become impossibilities!

"Swift flew the nimble keel; and as they past,
Long trails of light the shooting meteors cast;
E'en the fixed fires above in motion seem,
Shake through the blast and dart a quivering beam;
Black horrors on the gloomy ocean brood,
And in long ridges rolls the threatening flood;
While loud and louder murmuring winds arise,
And growl from every quarter of the skies."

It must have required a strong mind in those days of Augurs not to feel oneself tremble whilst describing such threatening phenomena.

Among the signs which indicated that the gods had forsaken us, was a phenomenon the possibility of which was admitted by Franklin; it was known by the name of cold fusion.

This ingenious author of *Poor Richard*, not the least apt to exaggerate, believed that the instantaneous action of lightning had the marvellous power of causing the fusion of metals without evolving the slightest degree of heat.

Arago shrank from this fact, which, if possible, appeared to belie the most elementary laws of physics, but which had nevertheless passed as an axiom among the ancient authors. Both Pliny and Seneca admitted, without any scruples, that the blade of a sword could be entirely melted in its scabbard without affecting the latter in the least. Pieces of money in a purse could also be melted so as to form, after the discharge, a single ingot. Lucretius speaks of the melting of bronze in similar circumstances. However, the facts thus related are too few or too ancient to enable us to form any opinion upon the subject, or to risk any ex-

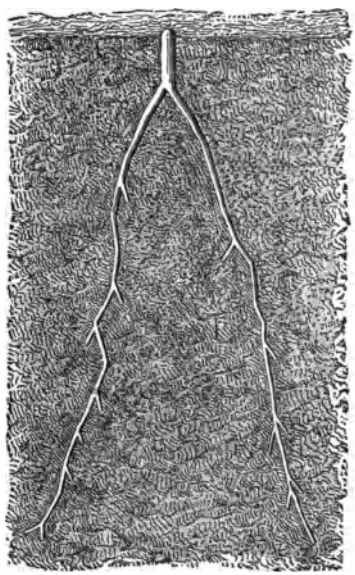
planation. Let us only remark, once again, that even in circumstances where the facts related do not appear admissible, the testimony of ancient writers should not be treated with contempt.

A worthy village curate, Pastor Hermann von Massel, had the good fortune to recover an observation which had been lost for centuries. He was tracing, in a German village, the course that the lightning had followed through the soil on its way to a sheet of water, where it lost itself. Its direction was marked by a tube formed by the vitrification of different substances in a very extraordinary manner. In fact, reactions produced under the influence of heat are so variable, that a systematic study of these tubes, aided by the use of the microscope, might lead to some curious results. How do we know that modern industry may not have owed something to lessons taught by the marvels of lightning? Who would dare to assert that it was not the sight of these circular tubes, the interior of which is like vitrified opal, that gave men of the primitive world the first idea of pottery? Would it not have been natural enough to endeavour to reproduce, with the fire they knew how to kindle, the effect of that which is shot from the hands of the gods themselves? Since the heavens manipulate so well with lightning, is it ridiculous to believe that they were interested in the education of nascent humanity? Why should not the myths of ancient paganism have a deep meaning attached to them? Do we not think, in spite of ourselves, of Prometheus drawing the fire from heaven, and of the vestal virgins who had charge of it?

At a period when the thoughts of Lucan had been forgotten in our desolated Europe, the Chinese were studying fulgurites (lightning tubes), with a care we were not yet capable of. They knew them better, perhaps, than we ourselves know them at the present day.

Missionaries inform us that the Emperor Kang-hi did not think it beneath him to make "*lightning stones*" the subject of numerous observations and researches, which some of our modern philosophers would think unworthy of their attention.

The dimensions of fulgurites, like all which pertains to natural electricity—the proper name for which, it appears to us, should be inconsiestncy—are extremely variable. We know some which are half an inch wide at the opening, and whose vitrified sides are rather more than an inch thick. Sometimes the traces of lightning can be followed in this manner for a distance of ten or twelve yards, which shows that the



Fulgurite.

discharge must have penetrated farther still. In cases so remarkable as these, the fulgurite has been the scene of intense calorific action. The sand near its sides has often undergone a kind of chemical or mineralogical transformation, due to a sort of metamorphic action, like that which is observed where the incandescent lava of our volcanoes has flowed.

It would appear, then, that the energy of lightning increases as it gets farther from the clouds, which give it birth. What confirms this opinion, so paradoxical at first sight—for it appears to belie every notion of mechanics which we possess—is the history of balloon ascents. Experience teaches us that they escape the action of lightning when they float in the midst of storm clouds. The same phenomenon renders comprehensible the fact so often mentioned, of mountain travellers passing through clouds whence lightning escaped incessantly, without meeting with the slightest harm. Should it not be said, then, of the danger of the thunderbolt, as of that of many other descriptions, that it diminishes for those who, instead of flying from it, rush boldly to meet it? Surprising and mysterious analogy between the moral and physical world, which the friends of nature feel every instant of their lives!

Captain Cook was in the port of Batavia, when a violent flash of lightning struck his ship, and this truly providential flash will teach us what happens in the interior of the earth, when lightning follows the course of a little conducting medium. The meteor produced no appreciable damage, neither in the body of the ship, nor in the rigging; but a copper wire, one-tenth of an inch thick, which reached from the summit of the mainmast to the water of the sea, into which it plunged, shone like a long streak of light, like a species of fiery rigging. If this wire had been buried in sand, a kind of superficial vitrification would, probably, have been produced along its entire length.

XXIV.

WHAT LIGHTNING CAN MELT.

THE first time that lightning struck the steamboat *New York*, on that remarkable day in which this vessel was twice visited by the meteor, it made its exit by a leaden tube which weighed about twelve pounds per foot. This massive tube was completely melted; unfortunately its length was not measured, but it must have been considerable. We should have known the number of calorific unities evolved, if the persons who observed this phenomenon had taken the trouble to give us the linear dimension of the tube, instead of telling us that it went from the captain's dressing-room to the sea.

The second stroke was observed under exceptionably favourable circumstances. The mainmast of the steamer was provided with a long iron rod, destined to carry a weathercock, and terminating in a point. To the end of this rod was attached a flexible chain, some forty yards long, which connected electrically the extremity of the mast and the ocean, the exposed conductor and the common reservoir. This chain would then have fulfilled its object marvellously well, and no phenomena of light or heat would have been observed, had it not been too weak to support the enormous mass of electrical matter which attacked it suddenly. It is not sufficient to call a thing a lightning-conductor; a conductor, *which is incapable* of supporting the discharge *that it invites, is liable* to be volatilized and to disap-

pear altogether.[1] This is, indeed, what happened after the second thunderbolt, for the chain was sought in vain; it had almost entirely disappeared, though it weigned certainly more than eight pounds. In spite of the most minute investigation, only a fragment a few inches long was found hanging to the extremity of the iron rod, which the fluid had respected. A small piece of the chain was enormously swollen, and two fragments which lay upon the deck furnished irrefutable testimony of the destruction of the chain by fire.

This observation, without precedent perhaps in the whole history of natural philosophy, furnishes us with the means of estimating the proper thickness of the conductor for the quantity of electricity produced. The chain might have been saved had its diameter been equal to that of the iron rod, which was rather more than half an inch, and escaped without the slightest mark. If it had been of this width, the electric fluid would have passed along it without producing any phenomenon, except that of an evolution of light, and the production of an insignificant amount of heat.

Copper, though a much better conductor of electricity than iron, is not sufficiently so, however, to allow these enormous discharges to pass over it without feeling their influence. As for gold, it is sometimes reduced to vapour, when its surface is not sufficiently large.

By a curious coincidence, the explosion which furnished the best proof that lightning always produces effects of deflagration, when it surpasses the force of the conductor, happened in Franklin's own house, where it volatilized a copper wire. It seems as if the fire of the heavens had felt the necessity of showing its power

[1] It was the knowledge of this fact which caused the new system of lightning conductors invented by the lamented Sir William Snow Harris, to meet with such success on many ships in the British navy. [Translator's note.]

to the very man who pretended to have the honour of governing it!

Again, we find in the *Philosophical Transactions* a curious report, written by a certain Captain Dibden, which we cannot pass over in silence. A thunderbolt fell in 1759 on a chapel in Martinique, which was provided with a lightning-conductor, though this means of protection was then in its infancy. The rod which the electric fluid struck was not less than an inch wide, and weighed, therefore, about two and a half to three pounds per foot. Nevertheless, the lightning, in a thousand times shorter space than will be required to read these lines, reduced it (if we must believe this writer) to the dimensions of an ordinary iron wire.

Just now it was lead and copper which were melted and volatilized in pounds' weight at a time; now it is iron itself which disappears in the same manner!

Who will then dare to impose a limit to this force, and say that it is not capable of forming cyclones, which it propels across the ocean, covering its waves with growling foam? Our eyes would be blind long before we could contemplate the most brilliant discharge that could be launched by this immense electrical machine, the cylinder or disk of which is represented by the earth, and the conductor by the clouds. Physicists will never measure the mechanical energy or the heat-producing properties of the most fearful of all thunderbolts.

XXV.

THE THUNDERBOLT WHICH STRUCK ANTRASME CHURCH.

THOUGH the great Frederick has not left behind him the smallest *disciple*, we must quote a very remarkable *observation* which suffices of itself to show that elec-

tricity has no caprices—that it faithfully obeys necessary attractions; in a word, that it is the slave of objects among which it moves. In the course of the year 1752, lightning struck the church of Antrasme. It descended from the bell-tower, following a tortuous path, and entered the aisle, where it did a great deal of damage. It melted the gilding of the picture-frames, it blackened the faces of the saints, it roasted certain rods of tin in the cupboards of the vestry, and finally it made its exit by two round holes, so regular and even that they might have been supposed to have been bored by a wimble, which passed through the floor of a lateral chapel. All traces of this accident were sought to be hidden as soon as possible; the frames were redecorated, the faces of the saints were washed, new rods of tin were bought, and the holes in the floor of the chapel were promptly filled up.

But on the 20th June, 1764, a little more than a hundred years ago, lightning again visited this church, striking the same tower, and penetrating a second time into the sanctuary.

What appears most strange—and we should not believe it had it not been vouched for by authors on whom we can perfectly rely—is, that the traces left by the second explosion were found to be identical with those of the first.

The thunderbolt contented itself with destroying the work which had been done to hide the traces of its former visit. The frames of the pictures were again ungilt, the faces of the saints blackened as before, the little rods of tin calcined, and the two holes in the floor of the chapel opened anew.

Let us seek for the probable explanation of this phenomenon. If lightning falls upon a certain point, it is because it finds itself attracted there by the nature of the substances around; it is because there exists a

natural affinity between the fire of the heavens and the matters which compose the soil, the edifice, and the subsoil. That which should be done to prevent the return of accidents, often so terrible in their effects, is to have recourse to science to discover a route which lightning will be obliged to follow in future, if we are not able to do away with substances which possess a dangerous attraction.

The remainder of the history of the church of Antrasme will complete the demonstration so perfectly begun by this extraordinary second stroke of lightning. Some time after the accident, the use of lightning conductors, which had just been invented by the learned American, became known. The building was then placed under the protection of an iron rod, arranged according to the precepts of the bold inventor. The success of the experiment was as complete as could have been wished for, in spite of the surprising coincidence of two successive strokes of lightning. The latter, now completely disarmed, has never again touched the frames, the saints, or the tin rods; and the holes in the floor of the chapel remain, to this day, stopped up.

Arago has remarked, with much truth, that the above facts were sufficient to convince him that, even in its slightest movements, lightning is never mistress of its own destiny. The fantastic rapidity of its course cannot in any way render it independent of an intimate connexion with things here below. In fact, there are millions to wager against one that it was not chance which caused the electric fluid to follow twice over exactly the same course at so long an interval of time; it can only be owing to the attraction of the objects themselves.

XXVI.

IS IT PRUDENT TO THROW ONESELF IN THE WATER TO AVOID LIGHTNING?

Do not imagine that we are treating lightly a subject so serious as that of thunder and lightning, when we propose to reply to the question which figures at the head of this section. It appears that the action of lightning upon some bathers was considered worthy of occupying the attention of the counsellors of a prince beyond the Rhine. I forget now in which principality, at present annexed to the kingdom of Prussia, it was that people had been forbidden to bathe during a storm. But since the battle of Sadowa, frightened folks are at liberty to seek refuge from the fire of the heavens in the waters of the Rhine, the Elbe, or the Maine.

At first sight such a precaution appears rather ridiculous; on a little reflection it will be understood that lightning which flashes in the clouds can strike living creatures plunged in water, even when swimming peacefully at a great depth. It is known that lightning does not require to strike a being directly in order to kill or to wound it. We know examples of the return-stroke, constant and secondary effects which are certainly not less dangerous than the original flash, and which appear to affect more especially beings which are not isolated from the common reservoir. What wider or easier communication can be conceived, than that of a sheet of water in which a bather sports himself? Medical men who prescribe electric baths have well understood that creatures who are naturally or accidentally

aquatic, are in the position of metallic animalculæ living in the midst of a liquid lightning-conductor,—in quicksilver, for instance. Can it be believed, if beings of such a nature could exist, that they would not be affected by an electric discharge from the clouds? No physicists would dare to uphold such an opinion! Who would be stupid enough—without going farther into the infinite field of hypothesis—to amuse himself by touching a lightning-conductor while the storm raged above? Physiology itself would suffice to assure us that fresh water, and especially salt water, is a very favourable medium for the slightest movements of electricity. Is it not in the class of fishes that we find beings organized to kill their prey at a distance by means of an electric shock? Is it not in water that swims those small living batteries called *Raja*, *Silura*, *Torpedo*, *Gymnotus*, *&c.*?

Nature has created no such fulminating animals in the aërial ocean. Why? Because in the atmosphere the fulgurating faculties would prove quite useless, for it would be almost impossible to give to the organs of a terrestrial being the power of producing lightning energetic enough to overcome the resistance of the slightest volume of air. It is because water is to be feared, that this marvellous apparatus has no parallel in non-aquatic animals, unless, indeed, we can be brought to believe that electricity is implied in the fixed stare of the serpent, when he fascinates the little birds which he afterwards devours!

Numerous examples, moreover, directly prove that rivers, at least, are not susceptible of protecting efficiently the beings which inhabit them. Not only are mariners and fishermen unanimous on this point, but the official history of electricity has preserved the recollection of some very remarkable accidents, though the victims were only unfortunate fish.

Arago relates that on the 17th September, 1772,

lightning struck the Doubs and killed all the trout which swam in that part of the river; the water was soon covered with dead fish floating on their backs.

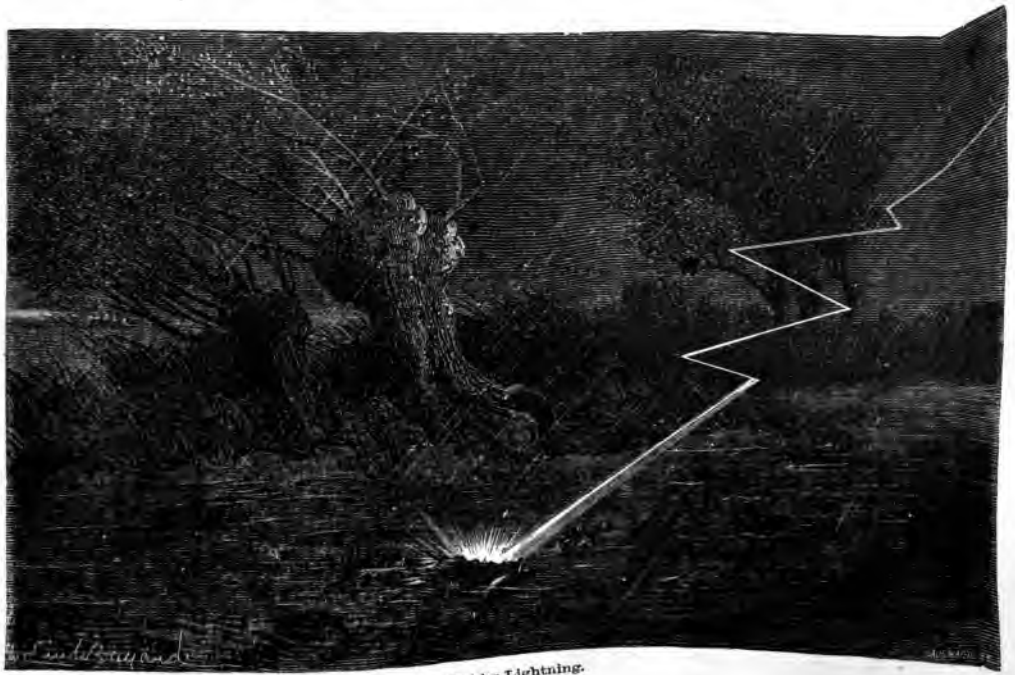
One century earlier, the almost subterraneous lake of Zirnitz had been the theatre of a similar event, but upon a much larger scale. The people in the neighbourhood collected an enormous quantity of fish killed by the electric flash; there were enough to fill eighteen carts.

Perhaps it is easier to kill a fish by lightning than a man; but I must confess that I should not like to have been swimming in that gigantic bath, so curiously encased among the rocks, when the phenomenon occurred. Lightning has certainly the power of reaching its victims wherever they may be, so that it is next to impossible to find in this respect perfect security.

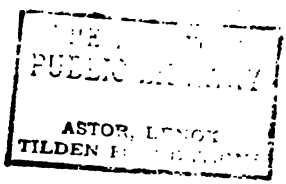
The *Annals* of Poggendorff, as we shall see presently, tell us that all the workmen engaged upon a lode in an iron mine felt a powerful shock from an electrical discharge in the air above, which certainly none of them could have heard.

Suppose that in this mine there had been a mass of water in communication with the common reservoir by damp veins of mineral; it will be owned that the inhabitants of such a subterranean lake would, to use a vulgar expression, have passed a miserable quarter of an hour.

In his *Notice sur le Tonnerre*, Arago quotes a number of examples to show that the tranquillity of subterranean waters is connected with the electric discharges of the clouds, and that they are agitated, sometimes, by the simple apparition in the sky of a few thin clouds scarcely visible, but nevertheless charged with electricity. How can we explain otherwise the movements of the fountain near Modena, described by Davini, the waters of which were generally transparent, but became turbid whenever the sky was covered with



Fish killed by Lightning.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clouds? It is this marvellous connection of that which is above with what is below, which proves that Vallisneri, the learned professor of Padua, was right whe he informed his colleague Toaldo that the salz s of Tibro, Guerzola, and Cessalæ surpassed the caprices of electricity, the most unsettled of the world's sovereigns.

Some distant thunder echoes in the depths of these fissures, a remote lightning-flash produces in them a species of fearful ebullition. Those who have seen this phenomenon will, perhaps, not blame the good men of Germany for their excessive prudence, and their solicitude about bathers.

According to this same meteorologist, Toaldo, there existed in the courtyard of a house in Vicenza, a deep well, which had the property of boiling up on the approach of a storm, producing enough noise to frighten the neighbours.

Perhaps the fright of these good folks was not so puerile as might be thought. Beccaria speaks of a storm which acted so energetically upon subterraneous waters, that it produced a disastrous inundation in the district. This catastrophe, originating in electricity, occurred in the middle of October 1755, and devastated nearly the whole vale of Piedmont.

The natural philosophers of the present century are not less explicit than their predecessors. In the Memoirs of the Academy of Prague, Nowack asserts that several springs which furnish excellent prognostications of the weather are known. Brandes stated that the evolution of carbonic acid from springs is connected with the presence of storm clouds. Cortellini says that the supply of certain hot springs would serve the purposes of a barometer. Here, then may be sought the explanation of many of the foregoing facts.

We might continue to produce quotations and to accumulate other remarks.

But let us restrict ourselves, on this special subject, to the preceding observations. Are they not rendered unnecessary, we might almost ask, by the solidarity which we find existing between the clouds and the ignivomous ocean?

Since the caprices of electricity descend as low as the ocean of flames, they cannot respect sheets of water lying in the intermediate regions.

Assuredly, it would not be reasonable to maintain, that the danger may be considered great enough to cause us to desert our river-baths when the weather is stormy. Certainly, no one would then trust himself in subterraneous basins, nor even descend into those natural fish tanks, that the rain has formed in ancient volcanic craters; but let us follow, without too much apprehension, if you please, the instinct which invites us to seek the fresh and limpid ripple. Only let us be aware that we shall not find in it a special protector, and that we are thus acting like those who stand at the foot of a tree for shelter in a storm, or like those who run to avoid the rain of the storm.

If one were to be exceedingly prudent, it would be necessary to avoid dangerous shades and rapid movements, which are not, perhaps, devoid of a certain unfavourable influence. All we can say is, between two evils, it is always prudent to choose the least, and to take proper precautions. What is to guarantee us from catarrhs and pleurisy, if we stand still and get wet by the rain out of respect for the thunder? But still, one must have lost his senses to go and take refuge in a river. Let us question our sensations, if we remember to have ever bathed during a storm. We might ask ourselves whether the fear we have sometimes experienced was not produced by some thunderbolt, or by some electric current, passing unexpectedly through the atmosphere? We would ask, again, whether this said fire

has not sometimes caused the death of certain unfortunate persons, believed to have been suffocated by submersion, but who in reality have been struck by lightning in the water of the river?

XXVII.

WILL THE DISCHARGE OF CANNON PREVENT A STORM?

MARINE waterspouts furnish us, certainly, with the most magnificent example which could be cited to show how immense is the power of man over nature, in those particular cases when he knows how to use it. Never probably can cannon-balls be better employed than when directed against these huge columns which the sea makes use of to invade the regions of the nimbus. Artillery really serves so little purpose in the world, that one ought never to omit quoting any case in which a ship of war has been saved by its guns.

According to many observations which we could bring forward here, in spite of the carelessness of the reporters, it is not permitted to turn to ridicule the opinion of persons who believe that the use of fire-arms may be efficacious against electric meteors.

Who would dare to blame those who had presence of mind enough to imitate Captain Napier, even in circumstances less serious? Would it not be logical to shoot off a gun in order to destroy globular lightning, which has been often seen wandering around an individual or an edifice?

The firing of a gun, producing a shock capable of destroying, as quickly as possible, this kind of natural bomb, which an unknown power throws in among us, would be, certainly, an excellent precaution, and a simple means of frequently preventing great harm.

But can cannon be used to disperse storm-clouds in ordinary circumstances?

That is a question which Arago courageously asked, in spite of the ridicule that certain narrow-minded persons endeavoured to throw on his researches. He did not fear to compromise, in the eyes of such individuals, his dignity as perpetual secretary to the Academy of Sciences. He has carefully verified an opinion which other would-be philosophers rejected *à priori*. This opinion is, however, tolerably ancient, and some distinguished writers have adhered to it with perseverance.

The Comte de Chevrier, the Marquis de Forbin, and the Bavarians, believed that storms may be repelled by salvos of artillery, and they have often burnt their powder at the clouds.

Statistical data have almost always been dealt out to science with a very miserly hand. Arago was obliged to content himself with information which chance threw in his way. But he solved this problem in a fashion which does so much honour to his imagination and sagacity, that we need not deplore the penury of the means to which he was reduced.

He had remarked that he heard from his cabinet at the Observatory, the report of the cannon, when artillery exercise was going on at Vincennes. It was a proof that the shock received by the air was transmitted from Vincennes to the headquarters of French astronomy. If cannon exercised any influence on the clouds, the influence would, therefore, be felt at this distance.

Luckily the days devoted to artillery exercise were spread pretty equally over the different seasons of the year, so that it was possible to apply the calculus of probabilities to determine the number of exercise-days, when the skies should be covered with cloud, if no external influence came to trouble the economy of the Parisian climate. On operating on some seven hundred

days, Arago assured himself that the sky should be found cloudy over the Observatory one hundred and thirty-seven times, if the artillery exercise at Vincennes had no influence whatever. The table of meteorological observations gave him one hundred and fifty-eight days on which the sky was cloudy,—that is, a notable excess of cloud.

We must conclude, from what has been said, that discharges of artillery must act upon the clouds, and that, consequently, the Marquis de Forbin was right so far, but the vibration of the cannon appeared to act in an unfavourable manner in a contrary sense to what the Bavarians and the Comte de Chevrier had imagined. The guns only invited the tempest!

What should be done, then, in a country well supplied with cannon, in order to complete this interesting demonstration? Evidently, we should multiply the remarks made by Arago; we should study the climate in the neighbourhood of artillery schools. How much powder has been burnt to increase the penetrating force of cannon-balls, their weight, or the distance to which they may be shot! A thousand plates have been pierced, a thousand kinds of grooves have been made to guide the ball and give strength and precision to the shot, and, nevertheless, the wish of Arago remains yet unnoticed fifteen years after his death!

An observation made by my younger brother, an officer in the Federal army, during the war in America, appears to show that those who, in peaceable times, do not think of Arago's ingenious calculation, are apt, in spite of themselves, to remember it in times of war. Almost always after a bloody battle, my brother noticed a violent storm break out. It would seem that the vibration of the air, the enormous quantities of heated gases formed by the combustion of gunpowder, the accumulation of conductible substances—men, animals

and instruments of war—which cluster on a field of battle, exercise a powerful influence on the state of the atmosphere, and provoke what the ancients would have called the fires of Jupiter. If the god of armies takes part in the fray, it is only to deluge with rain, in a very impartial manner, both the conquered and the conquerors.

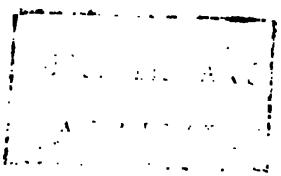
XXVIII.

THE DRAMA OF ELECTRICITY.

If learned men took into account the power which "the marvellous" exercises upon the impressionable minds of the people, they would endeavour not to allow superstition to take possession of that vague sense which invites us to believe all that we cannot understand, and to admire that which surpasses the limits of our daily observations. We think it necessary, then, to remark that modern scientific theories are far from banishing dramatic scenes from the subject which occupies us here. How often might not lightning still serve the purpose of the poet! If our modern Virgils and Lucans followed Moliere's advice, and took what belonged to them wherever they happened to find it, they might picture to us some very dramatic and sensational scenes.

Natural philosophy will not teach authors of the present day what help they may derive occasionally from the fire of the heavens, which plays such a grand part even in the *Æneid* of the prudent Virgil; but it might show them some new means of touching the heart, in imitation of those ancient writers who have succeeded in causing us true and sincere pleasure by remaining true and sincere in their descriptions, whether they had guessed the laws of the phenomena on which they

A Murderer struck by Lightning. 153



write—whether they followed mere tradition, or, what appears often very probable, whether their knowledge of science was deeper than our modern pride allows us to recognise.[1]

See here an assassin approaching his victim! He has chosen a dark, stormy night; he glides noiselessly between the trees of the forest . . . . He holds his breath whilst he draws his murderous weapon and raises it to strike his fellow-creature . . . . At this moment a brilliant flash of lightning illuminates the scene. An involuntary shriek escapes from the wretch, whose knife is snatched from his hand, whilst his inanimate corpse is rolled in the dust by an invincible and unseen power!

This is a scene of pure imagination; nevertheless, it is profoundly sensational, because such a circumstance might occur naturally. To bring out its probability, it would be wrong to neglect any of the circumstances which render it possible. The poetry would lose nothing by the poet reminding his readers that tall trees attract lightning, if the situation is such that the imagination of the writer reckons upon the attractive power of points.

Works on physical science certainly contain a number of scenes quite worthy of our melodramatic stage.

Arago relates that a brigand-chief, confined in one of the Bavarian prisons, was struck by lightning in the midst of his accomplices—probably whilst using blasphemous language to sustain their arrogance in presence of the authorities. The thunderbolt was doubtless attracted by the iron chain which bound him to the prison walls. But the phenomenon terrified the brigands quite as much as if the chain had not been there, and as if the lightning had chosen its victim expressly.

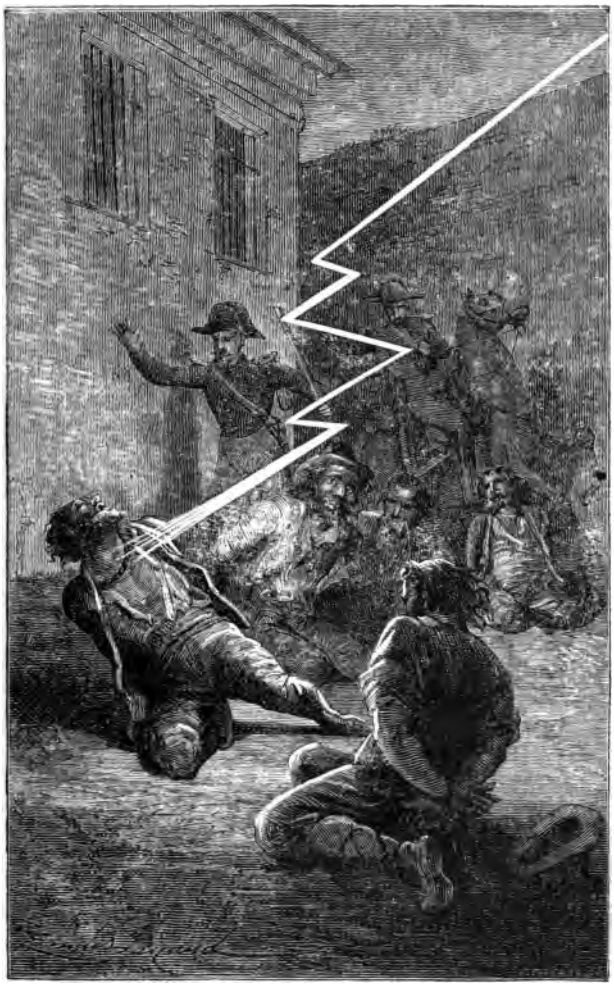
[1] On this subject our readers interested in the history of science cannot do better than consult the admirable pages of the second volume of Humboldt's "Cosmos."—TRANSLATOR.

The favorite of a prince has obtained a will, or rather an obligation, from his son. He reckons upon this document to trouble the affairs of the state after the death of his benefactor. He encloses it carefully in a metallic box, and buries it on the borders of a forest, thinking to hide it effectually from all search, even from that which the prince himself has commanded in order to repossess himself of this important document, wrung from him in a moment of intoxication. In the meanwhile lightning interferes! The tree is struck during a storm, the coffer hidden at its foot is broken open and hurled upon the road. A peasant passing soon afterwards, finds it!

Here is a lady, in sumptuous toilette, who has stepped out into her drawing-room balcony. She stretches forth her hand to know whether it rains or not, as she is about to leave her house. Does she go? She sees a sudden and brilliant light—it is lightning, which, attracted by her bracelet, melts it, and carries it off with a dexterity that would astonish a thief! Is it not a warning which will eventually change the whole story of the drama?

The *Annales Ecclésiastiques* relates that priests have been sometimes struck by lightning whilst officiating at divine service. The metal of the sacred pyx lifted on high has served to conduct the discharge to the head of the unfortunate mortal.

However, do not let us proceed too far in this direction—do not let us limit to a narrow sphere of action those unknown influences of a higher order. Let us not appear to deny the existence of causes which separate man from the Great Infinite. We cannot consider ourselves independent of the world, since we find physical reasons to explain what occurs around us, in our immediate neighbourhood, in the little corner which we inhabit. But should we find a thousand in-



Brigand struck by Lightning. 157

genious explanations for all these unexpected and fantastic phenomena, we cannot annihilate a fact so immense as the Universe itself. Is not the wonderful organization of man the result of causes infinitely more powerful, infinitely more intelligent, than anything which our intelligence can conceive?

Moreover, these strange events have a high philosophical bearing, for they prove to us that the "Cosmos" is not organized on the plan of a despotic state governed by arbitrary power.

They explain admirably to us that the infinite reality in which we exist cannot comprise beings which are independent of the most simple physical laws. They show us that it is false to say, even in the most extraordinary cases, that the rules which we are obliged to obey are only applicable to man—weak, humble, slave of lightning, proletary of eternity!

The physicist is certainly much embarrassed, when he wishes to choose between different suppositions, the best of which is not worth much, to explain the cause of globular lightning. But his efforts will never be lost; his errors may even contribute to the progress of science.

What benefit, on the contrary, do we derive from those narrow-minded, thick-headed, ignorant beings, who broadly deny everything which extends rather farther than the limited theories which they have adopted?

Phenomena which occur every day of our lives soon cease to astonish us. Thus the most elementary and useful laws have been called into evidence by some of their rarer manifestations. The theory of magnetism and electricity was brought to light by remarks on the attractive powers of amber and the loadstone, and not by one of those common phenomena in which the mysterious fluid manifests itself every day and every hour in a thousand different places, and before the eyes

of all the world. The subject of this volume would offer, if we succeeded in our task, many a magnificent example of the excessive importance of rare facts.

Happily, events calculated to astonish us are not yet of so exceptional a nature as to be stifled by indifference. They acquire such a degree of authenticity, that they impose on systematic incredulity. Then they serve to refresh science which, without them, would perish like that of the mandarins of the Celestial Empire.

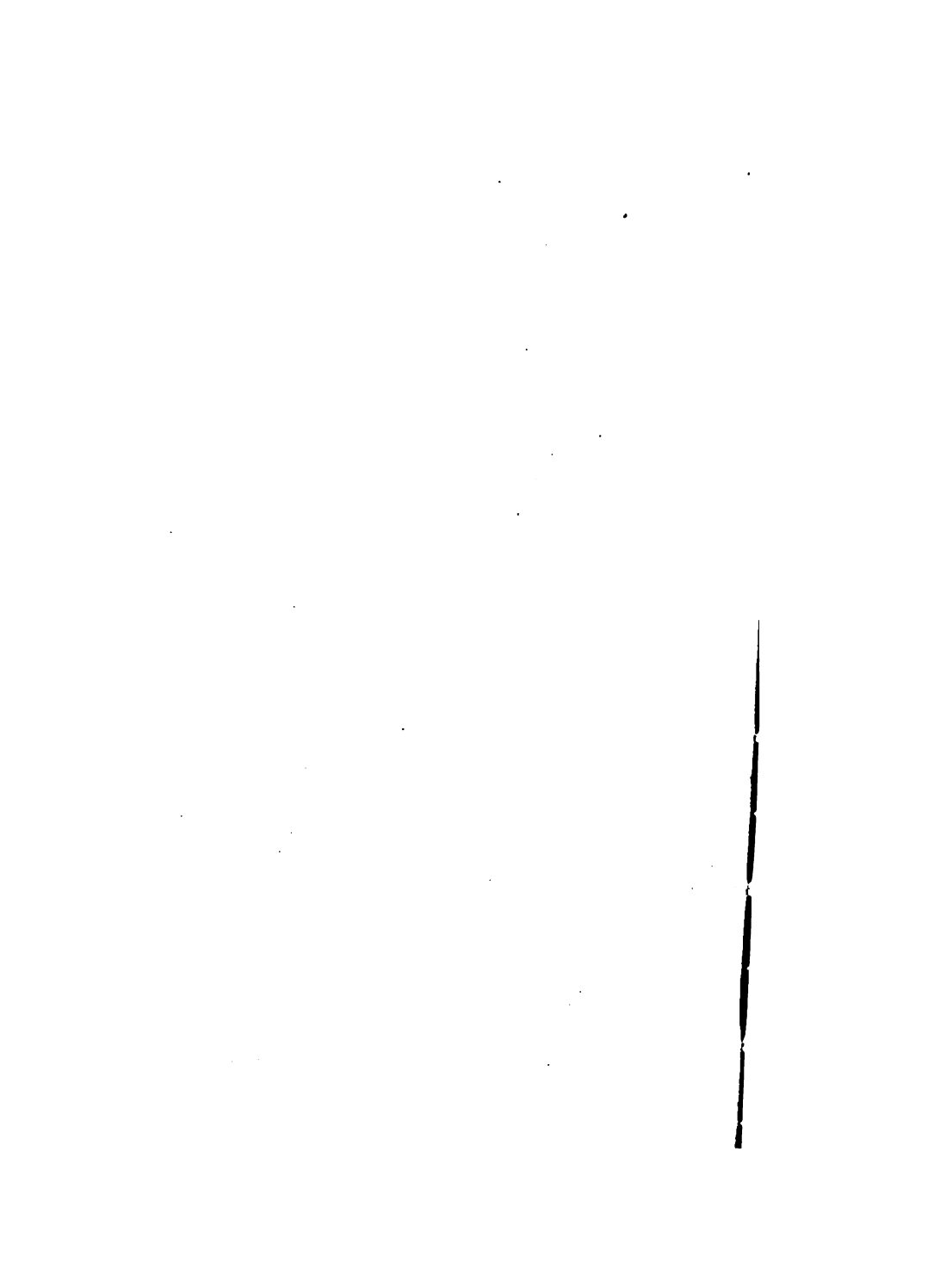
How many laws, still grander and more general perhaps than those we owe to Volta and Galvani, are at this moment showing glimpses of themselves! How many discoveries would enrich science, if we possessed the true explanation of all the authentic facts disseminated through our academical collections, and our journals, in works on general physics, on electricity, in the various essays on lightning! How many new roads are closed to us, because all these sources of wonderful information are entirely rejected by the timidity of most of our authors!

XXIX.

EFFECT OF A WALKING-STICK ON LIGHTNING.

On the 3rd Sep. 1789, a man was struck by lightning under an oak-tree, in the parish of Aylesford. When his inanimate corpse was removed from the spot, a wide and deep hole was seen in the soil. The lightning had produced in it the same kind of vitrification as in ordinary fulgurites, and it appeared to correspond in form with the stick which the unfortunate individual held in his hand when the flash occurred. The ease with which lightning travels over great distances is so familiar to

A Bracelet stolen by Lightning.



us, that we have no need to admit that in this case it had followed the course of such a bad conductor as a piece of wood. As it had quitted the tree to strike the man, so it must have left the body of the latter to run along the stick, which was doubtless tipped with iron.

Who knows but what this very circumstance caused the accident to happen? For we know cases in which peasants have been struck by the electric fluid because they wore wooden shoes bound round with sheet-iron. We dare not affirm that economical folks have not been punished for their parsimony, and struck dead, from having put too many hobnails in their boots, as others have been chastised likewise, for wearing with too much ostentation massive gold chains or other similar ornaments, or even for having too much metal in their purses! So much lightning falls from heaven, that there is evidently enough for everybody!

The *Phare de la Loire* newspaper reports an accident which occurred in the month of November 1815, and proves that it is dangerous for woodcutters to enter a forest during a storm. A workman, with an axe upon his shoulder, sought shelter under a tree, as will be done to the end of time, in spite of scientific warning. He had scarcely been there more than a few instants, when a flash of lightning, attracted by the iron of the axe, which he still held on his shoulder, struck him to the ground.

What imprudence! you will exclaim. But if he had remained exposed to the rain he risked catching fever and dying in a hospital. Lightning kills immediately and causes scarcely any pain, especially when one holds an axe in the air. If, however, he had thought of putting the axe, which must have been heavy to carry, upon the ground, between himself and the tree, that which *caused his death* might have saved his life. *Such is the way of the world!*

Is it possible, as I read in some paper, that lightning could have struck a stick which a man held in his hand without doing him any harm? The electric fluid, it is said, passed so near to his face, that he felt something like a breath of wind pass by, whilst his eyes were bathed in a flood of light.

Should these curious phenomena be rejected, however extraordinary they appear? Certainly not, if we imagine that the walking-stick acted as a conductor whilst the man's skin did not. Let us suppose that the hero of this strange adventure carried a sword-walking-stick and wore kid gloves; the phenomenon would certainly then appear much less extraordinary. But was it so? I cannot say, since history is silent. However, it is scarcely reasonable to wonder that these details should not have come down to us, though our incredulity offers no danger to the personal liberty or the purse of the narrator; but sword-walking-sticks are strictly forbidden by very wise laws, and our tribunals would not have looked upon the thunderbolt as an "attenuating circumstance" had the man been prosecuted for carrying such a weapon. Perhaps others may think that he was punished enough by the fright he experienced, however, brave by nature, at the moment of the electric discharge?

XXX.

CAN LIGHTNING MELT A CRYSTAL GOBLET WITHOUT BREAKING IT?

Boyle, the illustrious English chemist, who lived about two centuries ago, has described an accident which appears to me to contradict most singularly our notions of glass. Two large crystal goblets, cut with

much care and enriched with precious substances, stood one near the other on a sumptuous table which ornamented a richly furnished dining-room. Lightning took into its head to pay a visit to this opulent dwelling. The goblets were found in their places after the explosion had occurred, and, at first sight, it appeared that the thunderbolt had spurned them. But it was soon perceived, with much surprise, that both had been submitted to the action of an intense heat, which had melted them without causing them to crack! One of them had been so much disfigured that it stood upright with some difficulty.

Strange marvel! you will exclaim, if you are aware how delicately glass must be treated in order to change its form without causing it to break.

By what miracle were these two crystals able to bear, without the slightest preparation, a heat which would perhaps have been dangerous in an annealing oven, since it was sufficient to melt the goblets in the open air? How is it that these chosen vessels remained whole after having resisted the action of electricity, which submits less to contradiction than does the most arbitrary Sultan in the world, and causes everything which does not give it immediate passage to fly into a thousand fragments?

Two effects which appear equally opposed to preconceived ideas explain themselves one by the other. It might be said that certain contradictions mutually enlighten each other. In these extraordinary circumstances there appears to exist a kind of *interference* the reverse of that of light, for it causes light to appear, in these particular circumstances, when darkness is added to darkness.

The two vases which were the objects of this surprising observation were made of glass rich in oxide of lead, and consequently rather better conductors than

ordinary glass. However, their conductibility was not such as to allow a notable amount of electric fluid to pass over them without producing a great evolution of heat, quite sufficient to soften them. The fire which volatilizes gold, iron, and copper, is quite sufficient, it will be admitted, to liquefy glass, which is much less refractory.[1] Moreover this heat was developed, let us bear in mind, in the very interior of the substance; it did not act like that of our common ovens upon the outside of objects exposed to it. In fact, electricity heats objects in its own inimitable fashion. Every particle of the glass was raised instantaneously to a temperature which, however considerable, was the same at every point. It results that the heat was distributed equally and without producing any sudden shock liable to rupture the cohesion of the substance.

A glass which could not have borne a few drops of hot water without cracking had then melted like butter in the hands of the thunderbolt. The power of this agent of so many miracles had shown itself capable of changing one of the hardest and most fragile of matters into a substance as plastic as the clay of our sculptors.

XXXI.

LIGHTNING AND GUNPOWDER.

We could quote many examples to show that lightning sometimes scorns to have anything to do with gunpowder. It passes so lightly, so rapidly, that there is no time for an explosion to take place. However, we should be very wrong to conclude from this that powder

[1] It should be observed, also, that glass which contains a large proportion of oxide of lead is very much more fusible than our ordinary kinds of glass.—Translator.

must be considered as an inert substance from an electrical point of view, or as one that is incapable of acting upon the fulgurating matter. The substance which allows the smallest sovereign of Europe to launch his little thunderbolts possesses an incontestable affinity for Nature's gunpowder. Effectively we see lightning seek out gunpowder in hidden places, where men, alas! so nasty to make use of it, did not know that it existed.

Thus we learn that one day the fire of the heavens loudly revealed the existence of a powder magazine to some Mussulmans who were fast asleep and snoring on the top of the treasure. The awaking, true enough, was terrible, for most of these sleepers could only account to themselves for what had aroused them, in the paradise of Mahomet. If chemistry had not taught us that gunpowder contains a large amount of carbon, which is an eminently good conductor, atmospheric electricity would take upon itself to do so. In fact, if some conductible matter did not enter into the composition of this terrible instrument of war, we could not understand how it happens that a very small quantity of it can incontestably attract electricity from the clouds.

Ohm has taught us that substances of mediocre conductibility end by surpassing in this respect even gold and copper, if their mass is sufficiently great. It may then be asserted that *tons* of gunpowder accumulated in our arsenals, produce the same effect as *hundred-weights* of iron in a blacksmith's shop, or a forge. If the fire of the heavens falls so frequently upon accumulations of this destructive material, it is because the enormity of the contents of the magazines is concerned in the accident. Those who wish to preserve stores of gunpowder should, therefore, not reject any of the precautions indicated by science, however expensive they may appear.

We cannot but admire the haste with which the French Minister of War solicited instructions from the Academy of Sciences a few days after the thunderbolt of the 5th July, 1862, a remarkable meteor which struck the powder magazine of Bêthune, though it was provided with a lightning conductor in good condition. In fact, it is not without feelings of the greatest apprehension, that so careful an administrator of the immense interests confided to him by the public, can witness a globe of fire precipitated upon a casement filled with a substance of alarming inflammability.

The Academy of Sciences not having, up to the present day, elaborated the reply promised to the minister, we feel bound to quote the account of a disaster produced by the explosion of a powder magazine, which occurred about a hundred years ago. This frightful event happened at a period when government officers could not reproach themselves with anything; lightning conductors were scarcely known.

On the 18th August, 1765, lightning struck the tower of Saint Nazarus, at Brescia, a town which then formed part of the state of Venice.

This tower, according to Arago, reposed upon a subterranean magazine, in which were stored some two million pounds of gunpowder, belonging to the republic. The whole of this immense mass of combustible matter took fire at once, and with a rapidity that belongs to lightning alone. The effect surpassed anything which has ever been, either before or since, deplored by men. It is estimated that some three thousand people perished, victims of this furious explosion. A notable number of edifices in the large and fine town were overturned as if by an earthquake. As for the tower, it was launched into the air as a single block, and returned to the earth transformed into a shower of stones. The fragmen s were thrown to such

a distance that the author from whom we borrow these details forgets to mention it, fearing it might be thought that he exaggerated.

May we be allowed once more to observe that the frightful energy of these direful explosions shows that the electric fluid furnishes us with the most perfect means that could be imagined for letting off a large quantities of powder? The explosion takes place at the same instant in every point of the mass, with an *ensemble* which surpasses almost anything we can conceive!

XXXII.

STORMS ARE NOT AFFECTED BY BELLS.

In all parts of the world, the savages raise deafening shouts with the intention of stopping the eclipses of the sun and moon. The Indians that Columbus found in the Antilles, the Peruvians, the Mexicans, acted, in this respect, in the same manner as the present inhabitants of the shores of Lake Nyanza, or Lake Tschad.

Arago remarks, with much sense, that this character of generality which certain superstitions take, must be attributed to the necessity felt of benumbing oneself in order to overcome fear; the same craving can often be observed unawares in the midst of our civilized life as distinctly as among the savages.

Listen, says he, to the coward in the dark; he sings or he whistles! Look at a town in time of civil war; are they not always ringing the alarm bell, and firing off guns against some imaginary enemies, in order to keep up their courage? What a quantity of powder we should economize if we did not resemble the Chinese more than our vanity allows us to think we do!

Arago, although so lately lost to science that he may

still be termed one of our contemporaries, may have read in a ritual of his day the following prayer:—

"Let the bells chase away evil spirits, tempters, whirlwinds, thunder and lightning! Let them dissipate the snares of our enemy, the noise of the hailstones, hurricanes, and tempests."

Nearly such terms as these are still employed in our days, in the ceremony of blessing the bells of our churches.

It is in vain that several learned bishops have protested against this superstitious practice, in mandates which it would be well to renew in the midst of the scientific progress of the present day. It is in vain that the Academy of Sciences declared, as early as 1737, that those who rang church bells in stormy weather exposed themselves gratuitously to the danger of being suddenly crushed to death. How is it that these superstitious practices are propagated from generation to generation in spite of the rapid advance of learning and the light of modern discovery?

Every time that the alarm bell is rung to protect a canton from lightning, the right of saying that this troublesome noise saves the district, is there by acquired, if the lightning does not happen to fall in the neighbourhood. It might even be added, if the lightning did fall in spite of the ringing, that it was because the bellringers did not pull hard enough. In fact, one might go so far as to say, as a last resource, that the accident would have been incomparably greater if the magical powers of the bells had not been made use of. But this time the bronze could not do everything!

The Abbé Thiers takes good care not to mention this use of bells in his *Treatise on Superstition*, published about a century ago.

Collin de Plancy, who wrote upon the same subject not fifty years ago, is no bolder.

None of the co-editors of the *Encyclopédie Catholique*, published by the Abbé Migne, take the part of the courageous bishops who raised their voices against this superstition, as dangerous as it is ridiculous.

Bayle, who was not very credulous, however, thought it impossible not to acknowledge a fact so triumphantly established by witnesses of all kinds. He therefore endeavours to explain the action of the bells, and his explanation only causes us to regret the implicit faith of this naïve coal merchant.

In fact, the celebrated sceptic seeks to demonstrate with much difficulty, that lightning is produced by the falling of high clouds upon low ones which are nearer to us. Thus it is, says he, that the snow and ice of the Alps roll into the valleys beneath and fill the air with a hoarse roar.

Starting from such principles as these, it would be difficult indeed to arrive at any rational explanation. Also, after having tried to develop his fantastic thoughts in a few more paragraphs, Bayle adds that bells deliver us from the danger of storms, because they facilitate the dissolution of the clouds which are indispensable to produce thunder. For this physicist the paltry motion given by means of a rope to a few pounds' weight of bronze, is sufficient to cause the dissolution of clouds some miles high, and which cover thousands of square acres!

But Arago himself appears to hesitate before condemning formally this superstitious practice, which all the bishops had not endeavoured to cry down; for, after exposing, with his usual logic, the dangers of the practice, he attacks with extraordinary rigour the order issued by M. Marsillac, which he should have praised. He reproaches this honourable magistrate of the Department of Dordogne for having, in the year 1845, forbidden the ringing of bells during a storm, as an

elector of the Palatinate had done, however, towards the end of the last century, in an official document which deserves to be better known.

However, it will suffice here to borrow from the *Notice sur le Tonnerre* the account of what happened on the night of the 15th to 16th April, 1718, to establish upon an indestructible basis the demonstration of the imprudence of those who imagine that the danger of storms can be thus diminished.

The superstition relating to the imaginary power of bells was then very prevalent in Brittany; as soon as black clouds rose above the horizon, bells were rung in all the four-and-twenty churches in the neighbourhood of Saint Pol de-Léon.

Now, two phenomena happened which are equally remarkable. First of all, each of the four-and-twenty churches where the bells were rung was struck by lightning that did much damage to them. On the contrary, six curates who had allowed their bellringers to go to bed, had to congratulate themselves; the lightning did not touch any of their churches.

In order to maintain that, far from being useful, this ringing of bells was not prejudicial, many things must be totally forgotten, and especially the calculus of probabilities. For the latter shows that there exists 600,000 different manners of choosing six objects dispersed among thirty. Consequently, we are forced to admit that there were 600,000 chances against what happened precisely on that famous day.

Would it be logical in the face of this, to pretend that lightning had a kind of predilection for bells which vibrate in the church towers? We might as well reason like the folks who speculated upon gaining the great prize in the Mexican lottery.

But as there might exist in the world people credulous enough to remark, that the 15th April, 1718, hap-

Bell-ringer struck by Lightning. 173

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ıed on Good Friday, a day on which the use of bells Roman Catholic churches is forbidden, we feel bound quote another thunderbolt, which fell on the church 'er of Chabeuil, near Valence. That one fell in the lst of the Carnival time, when ringing was not forden, and at a moment when the bell-ropes were being led as lustily as possible to turn off the storm. The ıtning killed two of the eleven unfortunate individuwho had hold of the ropes, and wounded more or severely the nine others.

Can we be surprised at the electric fluid having been wn down in great quantities by the piece of metal, because it was in constant motion and vibrating with ›ecies of illusory hope, but because it was in conion with the common reservoir by means of a subıce sufficiently conductible? The hempen rope, proly damp, and the bodies of the bell-tollers, sufficed give it issue, and to produce the terrible result. The cific provoked the thunderbolt which, without it, ıld have been less terrible and less murderous.

XXXIII.

THE FISH OF JUPITER.

N the month of August 1844, an American ship ıght to Naples a living *Gymnotus*, or electric eel, ch had been caught at Valparaiso,[1] and deserves h more than the eagle to have been consecrated to iter, for it uses the lightning which it carries, whilst

'his was something like "taking coals to Newcastle," for there no less than three distinct species of *torpedo* (another kind of ric fish) in the Italian seas. These *torpedo*, as well as the more ole *gymnotus*, have been the object of some interesting rehes by *Matteucie* and Paul Savi. See their *Traité des Phenomè lectro-Physiologiques*, &c. Paris, 1844. [Translator's note.]

the eagle never let fall a single flash from its feet.[1] The fish was placed in a large metallic bath, filled with fresh water; and into this species of aquarium, frogs and little fish were thrown, to supply it with food.

It was then that a very extraordinary spectacle might be seen, which we will endeavour to describe.

When this terrible *Gymnotus* had chosen its prey, it approached slowly to within about a foot of its victim. It then stopped, and appeared to fix its eyes firmly upon it. The little animal was seen to be suddenly paralyzed: it remained quite motionless; its enemy had only to devour it.

Sometimes the *Gymnotus* appeared to kill, like some of our sportsmen, for the sake of killing only, as if it enjoyed making use of its marvellous power, of this strange fascination, similar to that which animal-magnetizers pretend to exercise.

When the famous king of the Goths, Alaric, besieged Rome, the commander of the Emperor's guard, as a last resource listened to the propositions of certain Etruscan charlatans, who pretended that they could draw down lightning upon the enemy. What they required was placed at their disposal, and their attempt ended in a most disastrous failure.

If it be true that human industry is destined to realize successively all the marvels presented to us by the animal world, the failure of which we speak should not discourage us. Whilst we recommend the Government to employ other lightning than that of the skies to pro-

[1] Some have pretended that the ancients must have observed the eagle alight upon the summit of the rocks, after having soared through high clouds charged with electricity. In this case, the bird being charged with the same electricity as the clouds, a spark might escape from its feet at the moment it was about to alight, which circumstance, perhaps, gave rise to the ancient manner of representing Jupiter as an eagle with lightning in its claws. [Translator's note.]

tect modern Rome from another Alaric, we may quietly assert, that the application of lightning to various arts must not be classed, perhaps, with the problems of squaring the circle, and perpetual motion. We may believe, without being imbued with ridiculous superstition, that Numa really may have found means of causing lightning to fall from the clouds, and destroy the offerings reserved for the gods. It may be permitted us to suppose that Tullus Hostilius was not really killed by discontented priests, but that he was struck by lightning because he did not make use of the precautions of his clever predecessor. Nothing can prevent our being struck with the strange legend preserved by Pliny, relating that the augurs of a certain city of Etruria succeeded in killing by lightning a monster which was devastating the country. This monster—strange coincidence, which manufacturers of extraordinary histories may some day make use of—was called Volta, the name of one of the greatest electricians that ever lived!

When electric fishes are in presence of their prey, their natural battery secretes the electric fluid in greater abundance, as we find the water come into our mouths, when we pass, very hungry, before the windows of a pastrycook's shop. The fish of Jupiter may then be assimilated to a metallic conductor, or to a cloud on which electricity might be accumulated by the action of certain internal mechanisms. The water in which the fish swims becomes electrified for some distance around it. Misfortune attends the innocent victim who swims unwittingly into this terrible sphere of action! For the little gudgeon or roach that approaches, is a better conductor than the liquid in which he swims without dreaming of the danger which is accumulating on his unlucky scales. As the unfortunate animal approaches, the *electrical tempest* which growls in the *organs of the Gymnotus* increases rapidly. When the

distance between the two is sufficiently small, the terrible current bursts forth, without noise and without light. The victim loses all consciousness, and abandons itself an easy prey to Jupiter's fish.

Messrs. Miranda and Pacci, the authors of these interesting observations, have made a very extraordinary remark. In fact they assure us that the *Gymnotus* appears capable of choosing its prey, for it does not always strike the fish which is nearest. Would this signify that the marvellous being possesses the faculty of directing its lightning where it pleases, which would make it appear much cleverer than the Etruscan charlatans, who were not able to prevent Alaric from plundering the Capitol; and might this circumstance serve to encourage those men of science who would be glad to find in electrical fire, a new means of destroying their fellow-creatures? Not at all. It is probably the little fish that sees its enemy, which is the first to be paralyzed by the electric fluid. The fright which it experiences serves to render it more liable to receive the shock. It is terror that delivers it up; it brings on its own ruin. This is how the *Gymnotus* appears to aim at its victim, with a precision similar to that with which a Prussian points his needle-gun.

Does not this observation supply us with a valuable lesson in philosophy? How much harm would people avoid, were they not possessed of pusillanimous fear! Epidemics, pestilences, dangers of every description, often fall upon us from mere want of courage. Whenever a person is struck by lightning, it is almost always partially by his own fault.

XXXIV.

LIGHTNING AND A SHIP'S COMPASS.

ARAGO found it related somewhere that lightning which fell one day into the shop of a Suabian cobbler, respected the person of the artisan himself, but had the singular effect of magnetizing all his tools.

The fantastic book in which the learned secretary of the Academy found this account, represents the cobbler in great dismay. His hammer, his pincers, his awl, attracted all the nails and needles of the establishment, and caused them to adhere firmly to the tools. The poor fellow thought everything in his shop had been bedevilled, or that he was dreaming.

The basis of this history may be considered as being perfectly authentic; for the *Philosophical Transactions* relates a fact of a similar nature, observed some time before we were made aware that iron can be rendered magnetic by the electric current, and at a period when it could not, therefore, have been imagined that the electricity of the clouds could act upon iron from a great distance, and modify some of its essential properties, without appearing to touch it.

In June 1731, a merchant of Wakefield had placed in a corner of his room a box of knives and forks, and other small iron tools, destined to be sent to the colonies. Attracted by the metal, the lightning which struck the house broke open the box and spread its contents upon the floor. When the different objects were *picked up, it was* noticed that they had acquired *new properties.* They had all been affected by the

discharge, those which remained intact as well as those which had been partially melted, for they had all become more or less magnetic. Not a single nail in the box but what might have served the purpose of a mariner's compass.

Every one knows now-a-days that pieces of iron of any shape, form, or weight, are transformed into temporary magnets whenever they are placed in such a direction that the magnetic influence of the earth can act upon them. It is sufficient to give them a twist whilst suspended parallel to the direction of a dipping-needle (a magnet freely suspended from its centre of gravity), to see them become permanent magnets. Here, then, we have the miracle performed by mechanical effort as well as by lightning itself. But in 1731, the phenomena naturally caused one to think of the occult sciences of necromancers, and of people who sought after the philosopher's stone. A century or so earlier, the cutler of Wakefield would have risked his life by speaking about what had occurred.

If the magnetizing faculty of lightning produces such marvellous effects on land, what must it not achieve on the wide ocean! For there the slightest fluctuations must influence the tiny movable needle which oscillates so freely under the eyes of the pilot; the slightest streak of lightning which slips unseen through the air may influence its precious indications.

It is now a long time since these phenomena were observed for the first time. In 1748, when the ship *Dover*, was struck by lightning, much of the ironwork of the vessel was suddenly treated like the aforesaid cobbler's tools.

When the packet-ship *New York* arrived at Liverpool, after undergoing the effects of the two successive thunderbolts which have rendered its name celebrated in the annals of science, several magnetic objects were

found on board. The nails and other objects of iron which formed part of the shattered mast, cabinet partitions, &c., the knives and forks which were in the biscuit store, even the steel points of certain mathematical instruments, were all magnetized.

We do not mean to say that, in this particular case, magnetism was developed very powerfully in these various objects. But there happened to be on board a very distinguished observer, Captain Scoresby, who never allowed a means of interrogating nature to escape him.

It is scarcely necessary to mention that magnetism developed in this manner on board ship, produces sometimes such terrible accidents that the troubling element betrays its own presence.

When it happens that a flash of lightning magnetizes the various steel pieces of a chronometer, the earth's magnetism at once acts upon these pieces and causes irregularity in its working. As the forces which are in action in the working of a clock are not very powerful, the attraction of the earth's poles upon the little magnets thus formed by lightning, causes their motion to accelerate or to slacken. Thus, the chronometers on board the *New York* were thirty-two minutes in advance of the true time when the ship entered port a few months after its departure.

On the night of the 21st to the 22d of February, 1812, lightning struck the ship *Golymin*, and wounded a certain M. Rihouet. All the steel pieces of a watch which hung near the head of this gentleman were so strongly magnetized on this occasion that the magnetism thus developed lasted for twenty-seven consecutive years.

Persons who know that chronometers are used on board ship for ascertaining longitude, will not be surprised to learn that magnetism produced by a stroke of

lightning has been, probably, the chief cause of many shipwrecks!

It will be asked, doubtless, whether we should not grapple seriously with this danger; if it would not be prudent to banish iron altogether from such delicate instruments as those required by navigators, and are indispensable to the safety of the ship. Perhaps such a precaution deserves to be considered whilst we endeavour to solve the problem of causing all the chronometers on board ship to work together with perfect regularity.

Sailors have often been laughed at when they asserted, on arriving at some port, that the compass had had its poles reversed without any visible cause. But as the compass needle is made of steel powerfully tempered, it is in the best possible condition to retain for a long time any modification provoked by the discharge of atmospheric electricity. Its magnetism may be lost or diminished, its poles may be reversed so that the one which pointed to the north now turns towards the south.

Arago relates two tragical events that were caused solely by this reversion of the poles. The first occasioned serious losses to the ship of war *La Baleine*, which he saw enter the port of Palma in a very sad condition. The second resulted in the entire loss of a Genoese ship, which struck upon the barbarous coast a few miles from Algiers. The few sailors who escaped drowning said that the captain, deceived by the reverse position taken by the compass, thought he was steering north when he struck upon the inhospitable rocks then inhabited by the soldiers of the Janissaries.

The same phenomenon occurred on board the ship *Albemarle*, some hundred leagues from Cape Cod, when it was violently struck by lightning, in July 1681. The masts, sails, and body of the ship were all more or less severely damaged. Luckily, the night was fine, and

enabled the sailors to see the stars. By this means they soon recognised that two of the three compasses on board were completely reversed, and that the third pointed due west instead of north.

The ship *Dover*, of which we have already spoken, was still less fortunate. It had four compass needles on board, when struck on the 9th January, 1748, and the poles of all were completely reversed. In this case also the phenomenon was immediately noticed, and so these two ships escaped injury.

Sometimes the stroke of lightning is just sufficient to take away completely the entire magnetism of a compass; the latter in this case becomes no better than an ordinary piece of iron.

This curious phenomenon was observed in several of the compasses on board the *New York*. Having completely lost their magnetism, they turned on their pivots in any direction, and pointed successively to all points of the horizon.

Silliman's Journal, the principal organ of American science, tells us that a similar accident happened to the ship *Medusa*, a brig sailing from Havre to Liverpool.

This time the ship was altogether deprived of a compass, for the four compasses which it possessed were all paralyzed most completely.

But it must sometimes happen that lightning increases the magnetism of a compass, and the calculus of probabilities teaches us that this effect must be at least as frequent as the other. It would occur when the electric fluid strikes the needle in the proper direction.

What must we conclude from the silence of history on this point? That the jealous lightning abstains from descending upon the earth whenever, by so doing, it might favour the designs of the little god which inhabits it! The fact to which we allude has never been

noticed for the very simple reason that men do not, as a rule, take notice of what does not constitute an unfavourable or disastrous event. If all the sinister pages were torn from the annals of humanity, there would remain in reality very little indeed!

We need not insist longer upon the phenomena related by nautical journals, the explanation of which is so simple. The direction of the compass with regard to the atmospheric current which strikes it may be such, that the magnetism developed by lightning is transversal, and the needle then acquires supplementary poles, which cause it to turn to the north-east, east, south-west, &c., instead of towards the north. The observation of the stars alone will enable us in such circumstances to determine the true course of the ship. When the stars are visible, the ship is saved. When once the cause of error is known, it can do no harm. A case is quoted of a vessel whose compass was reversed just as it started on a voyage of circumnavigation; it did not trouble to return to port and procure a new compass; nevertheless, it made its voyage without accident.

XXXV.

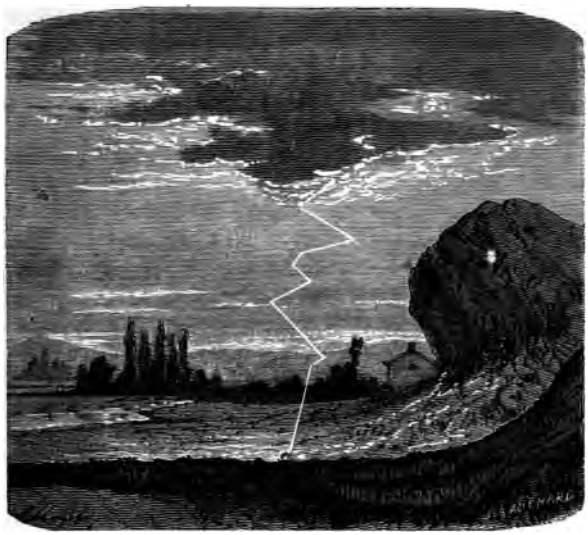
MAGNETIC MOUNTAINS AND LIGHTNING.

SINBAD the Sailor relates in his "*Travels*," that there exists near the North Pole a vast magnetic mountain of marvellous power, which draws nails out of ships, and is entirely covered with metallic objects attracted from the sea.

It is thus that the Arabian poet describes in his own fashion, the mines of loadstone which are plentiful in Scandinavia.

For many years it has been suspected that these remarkable masses of ironstone owe their magnetic pro-

perty to the spontaneous electric currents of which the interior of the earth's crust is the seat. The establishment of electric telegraphs has permitted us to go a step further, and to show that the magnetism of these immense mineral deposits is owing to the influence of



Lightning attracted by Metallic Lodes.

the Aurora Borealis. In fact, it has been frequently observed that the magnificent illuminations of the northern sky are accompanied by powerful currents which, as we observed before, progress constantly from the north towards the south. The metallic lode in the bowels of the earth acts towards this gigantic but harmonious lightning, in the same manner as the modest needle of a ship's compass. According to its mass, its purity, and more especially its direction, the ore of the

lode acquires an attractive (magnetic) force more or less considerable.

It is to this mineral (loadstone, magnetic iron ore) that we owe the origin of our knowledge of magnetism itself. Without this divine stone, according to Kircher, we should ignore a marvellous power which belongs, doubtless, to every planet. We may then pardon the fire of the heavens for troubling now and then our ship's compasses, for to it we are also indebted for the wonderful instrument itself, without which all navigation would be reduced to a little boating.

It is also to it that we owe the power of penetrating the harmony of worlds. Where shall we stop? We may safely say, Heaven alone knows, when we recollect discoveries such as those of Newton, and the insight they give us into Nature.

XXXVI.

STORMS AT SEA.

If civilized nations could agree and centralize the information they obtain relating to strokes of lightning at sea, it would be astonishing how many interesting observations might be collected. In fact, these phenomena are so frequent, that examples of a ship having been struck by lightning more than once are not at all rare. We might quote the ship *Rudder*, which was struck by lightning a second time one fortnight after having received a first discharge from the atmosphere; the ship *Saxon* was struck a second time just ten days after a similar accident; the *Massachusetts*, which received two flashes of lightning in the space of an hour; the *Louise*, which was struck six times in the same interval of time; and lastly, the *West Point*, which may

be said to have fought a regular battle with the storm. The storm was so fearful, and the electric influence so intense, that in the course of a few minutes this ship was struck seven distinct times, the discharges were terrible, and these seven celestial broadsides ended by killing a portion of the crew.

How can we reconcile such facts with the seductive theory, before mentioned, according to which there are comparatively few storms at sea? The solution of this astonishing paradox is tolerably easy by having recourse to the laws which we have already made use of on various occasions. Effectively, modern vessels, in the construction of which much iron is used, are in a good condition for attracting lightning most energetically. They determine, by sailing on the stormy seas, a number of electric discharges which, without their presence, would not have occurred.

If the masts were some hundred yards high, like the celebrated kite flown by Franklin, ships might be considered as immense discharges; fearful thunderbolts, prodigious sheets of fire, would accompany the navigator at each step. Luckily the relatively modest dimensions of our naval constructions render the danger infinitely less. However, the electrical influence which they really exercise is far from being unnoticeable; especially as regards men-of-war, which carry so much iron and gunpowder. Thus the registers of the British Admiralty show that from 1810 to 1815 only, the royal navy of England lost seventy vessels, put out of service by the fire of the storms. It might have been said that Jupiter had taken up the defence of the French, who were obliged to abandon the seas, and that he struck down with lightning the successors of Nelson, to revenge Napoleon I.

We prefer to state, simply, that the decomposition of the natural fluid was helped, as we before remarked, by

the accumulation of gunpowder on board the vessels belonging to his Britannic Majesty. That which tends to confirm our opinion in this respect, is the fact that one half of the ships placed out of service had two or three decks; the losses were felt therefore on ships of the line in a proportion far greater than their number. The favour shown by lightning to these ships proves that electricity chooses those which have on board a large amount of compromising cargo. As soon as peace was made, we see the number of lightning casualties diminish very notably in proportion. The heavens left them alone, because they had ceased to carry large quantities of gunpowder and cannon-balls.

Maritime flashes of lightning are sometimes of gigantic proportions; land storms, doubtless, do not allow us to form any idea of them, for those that have been described are fearful, and those which were still worse, of course, remain to be described.

Thus, not to quote other examples, we will remind our readers that from 1829 to 1830 the royal navy of England lost two vessels by lightning; both ships entirely disappeared with all their crews. Who can say how many shipwrecks are owed to lightning? How many ships have never returned from their cruises because they were not supplied with lightning conductors, or because, like the *New York*, their lightning conductor was too small? The invention of steam-ships and of vessels plated with iron would have given to the liability of being struck by lightning a truly frightful preponderance in modern times, had not the scientific investigation of lightning conductors progressed at the same time and in the same manner as maritime mechanics.

It is nevertheless true that had this not been the case we should not now-a-days have seen nations which call themselves civilized throwing away millions of money

to perfect themselves in the arts of attack and defence; the monstrous steel ships would not have shown their hideous scales in so many climates, for lightning would soon have done justice to these ugly products of the genius of destruction. But the fire of the heavens would have then compelled us to use the ancient modes of maritime transport. Without Franklin's discovery, steam-boats could not have plied the ocean. We may then congratulate ourselves, on the whole, in spite of the *Warrior*, the *Monitor*, the *Napoleon*, &c.

XXXVII.

FULGURATION FROM THE BODIES OF PERSONS STRUCK BY LIGHTNING.

THE Editor of the *Annales d'Hygiene*, M. Boudin, a gentleman much esteemed for his learning, relates, in a recently published paper, that the effects of lightning are capable of being transmitted to a distance after a certain interval of time. He quotes some very curious cases, in which people who have attempted to raise the body of a person killed by a thunderbolt, have received an electric shock themselves.

Who knows but what this marvellous effect was observed in ancient times, and that it is owing to it that lightning acquired its bad reputation? Must it not have been believed that the unfortunate individual whom the lightning had struck down belonged to the infernal gods, since an unknown agent struck dead those who approached to give help?

On the 30th June, 1854, a man was struck by lightning near the *Jardin des Plantes* at Paris. His body remained for some time exposed to the heavy rain, which would, one might imagine, have conducted

the electric fluid into the earth. When the storm had somewhat abated, two soldiers approached to lift up the dead body; but the moment they touched it, they received a violent electric shock accompanied by much pain. We need not ask whether they were surprised!

Three or four years ago, a storm burst over Zara, in Dalmatia, and overturned the electric telegraph. Two artillerymen were charged to put up the posts and readjust the wires. Who would imagine that these excellent conducting materials, which allow the current to pass with such astonishing facility, would have preserved an electric charge? However, such was the case; the two artillery-men received so powerful a shock that they were both knocked down.

One of them was rendered insensible; the other tried to raise himself, but he was again knocked down on touching one of his comrades who had run forward to help him. The latter, who received the lightning "*third*-hand," experienced some nervous disorder; moreover, his arm presented traces of a burn at the place where it had been touched by his comrade. The author of these observations does not tell us in what state the sky was when this extraordinary scene occurred.

XXXVIII.

LIGHTNING AND EMPERORS.

SEMELE, not content, says the legend, to receive Jupiter any longer in the humble disguise that he had taken besought her divine lover with so much warmth, that he was obliged to satisfy this caprice, of which he alone knew the danger.

The ambitious Semele was satisfied, but the lightning and thunder with which the god was accompanied was.

ıuch for mortal nature. She was instantly con-
d with fire. Jupiter had only just time to save
nborn babe, who was no other than Bacchus, to
ı we owe the knowledge of the vine and the use of

was natural that this poetic fable should leave
traces in the botanical and electrical opinions of
ıncients. Columella, who wrote twelve books on
ulture, speaks with eulogium of a person who had
l a means of preserving his dwelling from light-
which consisted in surrounding his house with
. More than two thousand years of experience,
ɔally adds Arago, have taught us nothing that
t justify the notion of transforming vines into
ning-conductors.

e Romans believed that many species of trees,
ımong them the laurel, are never struck by light-

Although too exclusive, this opinion is really
o ridiculous as some people have thought. The
ts of trees which contain much resin, caoutchouc,
ıhor, and other substances which are bad conduc-
ɔf electricity, may be considered as being tolerably
ting in most cases, in spite of the attracting power
ɔints. But the ancients were fond of developing a
ı as far as possible. Not only Ajax, son of Oileus,
punished by Jupiter for his impiety, and was
ged into a rock, but Neptune contributed to the
ishment by striking the rock asunder at one stroke
is trident.

ɔcording to this belief, they had made of the leaves
ɛrtain resinous trees a kind of talisman to repel
ning; thus Suetonius tells us, in the *Life of Tibe-*
that the host of Capreæ placed on his head a
n of laurel whenever he heard the sound of
der. This suspicious prince, who thought he had
f from his enemies all chances of assassinating

him, wished to insure himself against the fate which had awaited Tullus Hostilius. He never dreamt of Macro's cushions.

Lightning appears, at first sight, to have been the death of so many princes that the fear of Tiberius may be well imagined. But severe minds may think that the disappearance of these princes is almost always like that of Romulus, in which people put no faith, in spite of the suspicious testimony of Julius Proculus.

Do we not recognize the hand of the assassin in the dreadful fate of Caius? Had not this emperor (said to have been struck by lightning) that sanguinary man, Arius Aper, in his staff, whom Diocletian afterwards killed by torture, for murdering Numerian? Can we believe that the fire of the heavens really struck the Emperor Anastasius? It may be so, but we must forget that this prince persecuted the priests, and had the misfortune to excite theological hatred, the most unforgiving of all, and more to be feared than all the meteors in the universe.

In general, lightning appears to have respected sovereigns, and has only struck those around them; though in our own times, the young King of Greece, when on board ship, was knocked down by a thunderbolt. Thus, history tells us that when the lightning fell on the litter of Augustus, during his expedition against the Cantabri, it did not do him the slightest harm, but killed the slave who carried the light.

Eginhard speaks of a similar occurrence *a-propos* of Charlemagne. The horse he rode was killed by a violent discharge of lightning, but the rider was not hurt. Was it the hand of Providence which thus protected so glorious a king?

It must not be believed that high rank gives any special immunity; it would be more prudent to recollect what happens when several persons join hands and put

themselves in communication with an electrical machine. Who does not know that the persons situated at the extremities of this living chain receive the most intense shock, and that, sometimes, they alone receive any shock at all? Men walking one behind another may be considered in a similar position as those who join hands in the above experiment. Now, it is rare that majesty goes alone, without couriers, guards, escorts, suites, &c., for fear, not of lightning, but of men. If lightning, attracted sometimes by the embroidery or the sceptre of the monarch, strikes at his feet, it is generally those around who pay the penalty.

XXXIX.

ADVANTAGE OF HAVING SMALL FEET.

WHEN the lightning struck M. d'Aussac, on the 12th of August, 1783, this unfortunate gentleman was not the only person riding along the unlucky road; at his side were M. de Gontrau and M. de Lavalongue, whose horses were killed, as his was. How can we account for the marvellous escape of his two companions? Who will tell us how the lightning came to choose two victims out of the four hundred spectators in the theatre of Mantua? Who can guess how the lightning which struck the theatre of Feltre, on the night of the 26th to 27th July, 1779, happened to kill ten particular individuals?

But what appears to us, without any doubt, still more curious, is the fact of certain persons who, whilst doing nothing particularly likely to attract the fire of the heavens, were struck by lightning several distinct times, and at several years' interval. How can we understand, unless lightning feels a certain satisfaction in re-open-

ing old wounds, that Father Bosco should have been struck three distinct times, at six years' interval, and in three different houses? Does not the fulgurating matter obey certain secret affinities similar to those which draw it on board a man-of-war? The repetition of an event as rare as that of gaining a prize at a lottery, should be perfectly miraculous.

What can be said, again, of the strange circumstance of Mrs. Haines, an American lady living in Indiana, who was twice struck by lightning on her foot?

Must the property of attracting lightning be assimilated to that of showing the curious electric aureola? Are the most eminent, the most sympathetic, the most nervous men, more menaced than others by the fire of the heavens? Does lightning, as a rule, prove itself an enemy to anybody or anything superior?

The following anecdote will show, on the contrary, that the electric fluid appears to be more dangerous to animals than to men; and that the more animated beings are exposed to it, the more refractory their bodies prove to its passage on transmission. Lightning, says the chronicle, struck the famous Abbey de Noirmoutiers, in the year 1715; it killed twenty-two horses in the stables, but it did no harm to the hundred and fifty ecclesiastics assembled in the refectory. It, nevertheless, struck that particular part of the building, for it overturned, or caused to be overturned, the bottle which each reverend father had before him, and which contained his allowance.

Certain authentic reports appear to prove that the human race is that which lives the best in the society of lightning; as if the storm were susceptible of indulgence for the being charged with forming an opinion upon the things of this world, and with the exercise of volition and reason.

On the 26th of September, 1820, lightning struck a

labourer whilst working hard at the plough; the shock was so violent that the two poor animals were struck dead by the side of the peasant. The latter, in a little while, came to himself again, and after remaining a few minutes on the ground in utter astonishment rose up, safe and sound, though somewhat frightened.

On the 13th of August, 1862, a farmer of St. George-sur-Sarre was driving a cart with four oxen, when lightning fell in the midst of the group. Two of the animals were killed, a third was thrown upon his side, with one-half of his body completely paralyzed. Will it be believed that the farmer, in the presence of this fearful electric discharge, capable of knocking down three oxen—three beings so slightly nervous—felt only a little giddiness?

The ancients pretended that the eagle and the walrus were invulnerable animals. This belief resulted, evidently, from error, for of all animals the most difficult to be struck by lightning is certainly man himself; it seems as if the fire of the heavens respected the high-priest of thought!

The thunderbolt which fell in 1526, near Worcester, preferred a colt to the child who was leading it to the drinking trough. In the ninth year of the Republic, the electric spark of the atmosphere having to choose between a horse, a mule, and a carter, took the horse and the mule, but respected the man.

In 1810, lightning entered the house of a M. Corven, who was playing with a dog. It killed the dog, but did no harm to its master!

Nine years later the electric fluid struck the church of Château-Neuf. It killed only five persons out of the two hundred who were assembled there. But none of the dogs who had slipped into the building at the same time as the faithful, escaped; they were all suffocated without pity.

On the 9th of May, 1855, a thunderbolt fell in a field belonging to the parish of St. Leger, where there were, at that moment, a flock of seventy-eight sheep and two dogs. All these animals were killed dead on the spot, but the woman who guarded the flock was only slightly shaken. Even in those cases where the shepherd partakes of the fate of his flock, the animals are rather more severely treated than he is.

On the 11th of May, 1865, about half-past six in the evening, a formidable peal of thunder was heard on the summit of the mountain called Gay-Vieux-Sarts. The shepherd of a flock which grazed there was not spared; he was killed along with one hundred and twenty-six sheep under his charge. When the dead bodies were removed, it was found that the man's hair had been torn off, and that his dress was torn to shreds. A small metallic crucifix had been tossed sixteen yards away. The sheep had been mutilated in a frightful manner: some had their heads pierced from side to side; others had their throats cut as neatly as if they had been guillotined.

But it is not only among different species of animals that these strange preferences of lightning are manifested; even in the bosom of the privileged race itself, we are able to note remarkable differences. It is impossible not to imagine that nature has felt the necessity of preserving negroes, as if they were exposed to exceptional dangers. It is known that the skin of our black brethren is so strongly isolating, that a negro, introduced into an electric chain, generally arrests the shock!

On the other hand, the number of women struck by lightning is so small in comparison with the number of men in spite of the fine delicate skin of the former being an excellent conductor, that, we may safely affirm, lightning appears to honour them with singular affection. *It is true*, however, that the number of women exposed

to storms is relatively smaller. The male sex is, in general, given to the outdoor, vagabond professions, among which lightning exercises its disimal conscription.

But it is possible to quote a certain number of examples, which might lead us to believe that women, situated in the middle of a group of men, enjoy an immunity almost as great as that of a shepherd in the midst of his flock.

On the 1st of August, 1854, lightning fell at Pierrecourt, in the department of Haute Saône; it struck, in the middle of a field, both a man and a woman, who were working at each other's side. The man was killed instantly, but the woman escaped; she only experienced a kind of temporary paralysis.

The thunderbolt which fell at Maileret is still more instructive. A family composed of five persons—the mother, two sons, and two daughters—took refuge under a tree, during a violent storm. The lightning struck in the midst of this group: one of the sons was killed and the other wounded; the two daughters escaped with fright; the mother alone experienced a commotion probably sufficient to strike down a man or a bullock: she received only a slight wound.

On the 27th of May, 1853, the atmospheric spark fell at Agremont, a village in the department du Gard. It struck a group composed of seven women and a shepherd. The latter fell dead instantly; the seven women, though knocked down, soon arose, quite well, perhaps in better health than before.

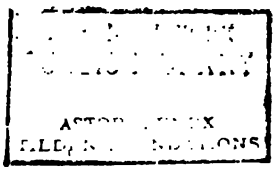
On the 17th of August, 1863, about three o'clock in the afternoon, a violent peal of thunder roared over Hutterdorf, a village in the Rhine provinces. The lightning fell again among a group composed of a man, a young girl, and a child. The man was killed, whilst the girl and child received no hurt. However, in this

case, the effect of the electric discharge appears to have been very terrible, for the dynamical properties of the lightning persisted in a singular manner. Twice the girl and the child rose from the ground, and twice they were thrown down again by an unknown, invincible force. At the third attempt only were they able to remain standing, and to go forward, with the intention of assisting the unfortunate individual who lay dead at their feet.

An animated being acts evidently towards lightning as a piece of metal does. The more nervous, the more impressionable, the better conductor a person is, the less he or she need fear the effects of the fulgurating matter. Perhaps, it must be supposed, as we said before, that the more intelligent races of men may live in peace in the midst of thunder and lightning. But, nevertheless, the negro is not more intelligent than the white man.

However, it does not require to be a good naturalist, in order to perceive that the surface in contact with the common reservoir, is so much the wider and more perfect, as the being himself is largely built and supported upon large, rudely sculptured limbs. Heavily weighing upon their four columns, quadrupeds offer evidently an enormous *surface of communication*. Although taller in figure, men must be, when everything is taken in account, less susceptible of attracting the electric discharge. Besides, their permanent conductibility being greater, the effects of the passage of the same quantity of electric fluid must be less disastrous to their organism. Their feet are generally isolated by stockings or leather gaiters, which protect them at once from the fire of the heavens and the damp of the earth, whilst horses have their feet generally armed with iron shoes. The horseshoe, which causes the

Umbrella and Lightning Conductor. 199



spark to rise from the stone pavement, can also attract the electric spark of the atmosphere!

Lighter still, and more delicate in figure, women run much less risk from lightning than men; unless, indeed, fashion happens to give birth to certain special dangers, such as we have before noticed. If fine ladies have lost their lives on account of the number or size of their gold ornaments, simple shepherdesses have been saved, because they would not wear iron-bound clogs only fit for the farmers' boys. As long as it is not excessive, the love of beauty, which is innate in their hearts, therefore diminishes rather than increases the danger; and as far as lightning is concerned, it is certainly advantageous to have small feet!

XL.

DANGERS OF RICHES AND COQUETRY.

SUETONIUS tells us that Augustus wore the skin of a sea-calf, to protect himself from lightning, which the Cæsars appeared to have feared, as we have already seen, quite as much as they did conspirators. It may be that the legend of Romulus was the cause of this; perhaps they feared that Jupiter would revenge the Roman liberty dishonoured since the time of Brutus. The wily founder of the empire might have chosen a worse object to protect his royal person from a sly flash of lightning, for the tunic thus made of a thick oily material is not easily penetrated by electricity. It must evidently be considered as a screen as efficacious as the silk dress of an elegant lady, or the stole of a priest. Now we have many examples of young ladies whom silk has protected in a miraculous manner. Our maternal grandfather relates, in his *Mémoires*, that he

was struck by lightning that fell upon a silk umbrella which he held open. He saw himself enveloped in a vortex of flame, and believed himself saved by Divine protection. Never dreaming that the silk covering of his umbrella might have had something to do with the miracle, this circumstance caused him to become an ecclesiastic.

Gold ornaments, and all kinds of metallic objects which enter into the costume of a traveller, produce a contrary effect, and attract lightning sometimes, with marvellous facility. We may perhaps be allowed to quote a few instructive cases.

About a hundred years ago, De Saussure and his companions were overtaken by a storm on the summit of the Breven. The atmosphere was so strongly charged with electricity, that each of the tourists felt a peculiar pricking sensation, when he raised his hands in the air. This sensation was owing to the passage of a jet of electricity, which, emanating from the rocks at their feet, dissipated itself through their bodies into the air above, as happened to the naturalist, Siemens, on the top of the pyramid of Giseh. One of the travellers, who had a gold braiding to his hat, was not obliged to make any movement in order to invite the discharge. He heard a constant and frightful buzzing noise around his head. Whenever one of the others approached his hand to a gold button on the hat of this gentleman, a vivid spark was drawn from it.

Arago relates, on the faith of a German author, a still more characteristic anecdote concerning a young damsel who lost a gold pin which served to fasten her hair; the lightning had melted this ornament without injuring the wearer.

It is a strange analogy, well worthy of fixing the attention of philosophers! These jewels, which have the privilege of attracting our gaze and of fixing our

eyes upon them by an unaccountable species of magnetism, appear also to incite the secret affinities of lightning.[1]

This special and very real danger attracted, no doubt too vividly, the attention of the celebrated Bridone. Despairing of ever seeing the fair sex abandon that love of jewellery, that species of hypnotism which so often increases their charms, the learned traveller proposed a remedy for the danger in the shape of a mechanical apparatus. He imagined a portable lightning-conductor for the use of elegant ladies and gentlemen; he proposed that they should each carry a little chain, or iron wire, to be attached in stormy weather to the metallic portions of a lady's head-dress. It appeared to him, truly enough, that the electric fluid would run down this chain to the ground more easily than if it were forced to travel through the head and body of the person, thus producing death, or at least a most violent shock. A furious ecclesiastic of the period declared that it was better to have the women exposed to the fire of the heavens. "When one of these sinners is struck by lightning," he exclaimed, "it serves to frighten the others!" The use of steel hoops, which constitute the soul of crinolines, would appear to have increased the liability of the fair sex to lightning, enough so, indeed, to have almost annihilated the evident immunity which women have hitherto enjoyed. However, the statistic accounts of the learned M. Boudin do not appear to have established that the number of women

[1] This remark, in the present state of science, applies only to metallic ornaments. Precious stones would appear at first sight to be in no way connected with electricity; but several of them, particularly tourmalin and certain other minerals, such as calamine, possess very remarkable electrical properties. How far these properties may enable the stones to attract lightning, or to act upon our senses through the medium of the nerves, is as yet an unsolved problem. [Translator's note.]

struck by lightning has notably increased since the introduction of that expensive fashion. Perhaps the habit of wearing silk dresses, which has generally increased of late years, has served to counterbalance the prejudicial effects of the steel cages. Moreover, village maidens, who furnish the largest quota of female deaths by electricity, have not yet adopted the fashion of wearing crinolines in the fields where they tend the swine, the sheep, the geese, or the turkeys.

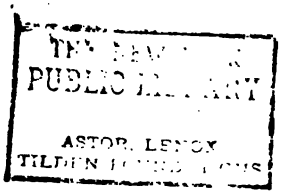
However this may be, the invention of the worthy Bridone is far from being the most ridiculous that has been proposed for insuring a person against lightning. A philosopher of the last century imagined an umbrella lightning-conductor, made of silk, of course, but having a metallic point connected with the earth by a chain drawn after the person as he walked.

Doubtless no one has forgotten the metaphorical advice given by Socrates to his disciples, that they should construct themselves a glass house. Our readers will certainly be surprised to hear that some timid individuals, dreading a thunderbolt, have followed *literally* the philosopher's advice.

It must not be imagined, however, that it is really so very easy to protect one's self completely, so as to obtain what might be termed absolute security.

Take care of currents of air, said the old women, and what Arago states to prove them wrong does not completely satisfy us. Take care still more to avoid chimneys, for lightning has often been seen to run up and down them. In fact, the soot which lines them is a good conductor. That might be done away with by sweeping the chimneys frequently. But who will trust to chimney-sweeps when it is found that proper metallic conducting rods can scarcely be trusted, their action being often compromised by faulty arrangement, or by the imperfect conductibility of the chains?

Bell-glass Preserve. 205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XLI.

THE SMALL CHANGE OF LIGHTNING.

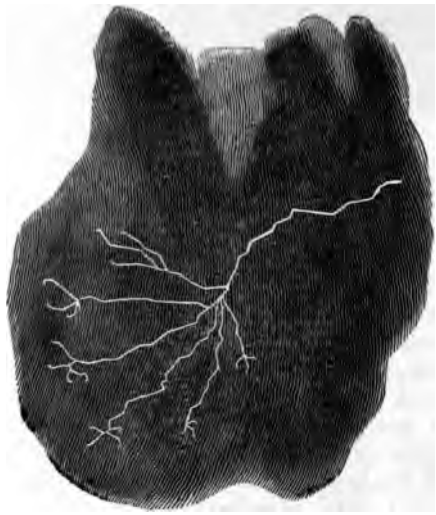
In 1850, Dr. Joule, a celebrated physicist, established for many years at Manchester, observed during a violent storm, a magnificent example of the dispersion of lightning. A splendid luminous tree, with a trunk boldly designed, and branches offering an infinite number of ramifications, showed itself suddenly in the clouds.

M. Liais, in his magnificent work *L'Espace Céleste*, also gives a figure of a splendid flash of arborescent lightning, seen by him during his voyage to Brazil.

These phenomena show us, most evidently, that the fire of the heavens is susceptible of infinite division, similar to that which is remarked in the electric current of Volta's pile.

Electricity, whose ambition appears to be immense, seems to precipitate itself at once in every conceivable direction, into every route that is open to it; it is thus that the quiet currents of the voltaic battery are divided among the different branches of a metallic circuit. There appears to be no limit to this marvellous separation or division.

The law of Ohm reigns then absolutely in the heavens, as well as in the laboratory or the electric telegraph, the circuit of which is completed by means of the conducting power of the earth. This fact is received by certain authors with surprise, much akin to incredulity. Indeed, in observations relating to lightning, there is always a wide door open to scepticism. How can we rely on the evidence of the senses in cases where the observation can only have a duration equal to some



Ramified Lightning.

imperceptible fraction of a second? When will the day arrive that photographers will be clever enough to employ their art in determining the figure of lightning? When will they do deliberately what the photographer of Berlin did in spite of himself, when he fixed the image of an invisible flash of lightning, emanating from the lance of the statue of an Amazon?[1]

In certain cases, fortunately, lightning leaves witnesses upon whose perfect good faith we can rely.

In August 1777, a thunderbolt broke the iron cross

[1] A recent number of the *Moniteur de la Photographie* relates that attempts in this direction have been already begun in New York. Some photographic proofs representing a portion of the town were obtained during a violent storm, the background of the pictures being vividly lighted up by the electric flash. [Translator's note.]

which terminates the tower of the church of Cremona. It projected far away the copper-tinned weathercock, which turned just beneath the cross, and was covered on both sides by a thick layer of paint.

When this piece of metal work was picked up, it was found to be pierced with eighteen holes, the borders of which were all parallel, but reversed alternately, nine standing out on one surface, and nine on the other.

Between how many circumstances should we not be condemned to choose, if we would look upon this as a pure effect of chance?

Does it not appear to demonstrate forcibly that the electric matter, contained in the interior of the weathercock, had exploded outwardly, with furious energy? Shut up everywhere by the isolating layer of paint, it broke it open with force, producing the eighteen holes, parallel breaches by which it instantaneously escaped.

The small change of lightning is terrible. Each separate flash or ramification has the power of dealing death, so great is the energy of this invisible, impalpable, incomprehensible fluid, of which the molecules of all matter appear to be saturated, impregnated, in such enormous quantity, that it is impossible to give a measure of it.

Thus, on the 28th June, 1865, lightning fell about seven o'clock in the evening, in the midst of a group of labourers, sixteen in number, who were working near the mill at Loragen, parish of Coray (Finisterre). Though divided into sixteen branches, the lightning was none the less powerful. It made sixteen victims: six were knocked down, three received powerful contusions, and the seven others were killed. The clothes of the men who were killed were torn and thrown from their bodies to a great distance.

At Tullahoma, Tennessee, on the 18th June, 1865, about two o'clock in the afternoon, at guard mounting,

the soldiers saw a vivid flash of lightning traverse the sky, and at the same instant was heard one of those fearful peals of thunder which have caused it to be said, that Nature does everything on a grander scale in America than in Europe. All the men of the relieved guard, and some of those who arrived, were knocked down instantly. The shock was so violent, that those in the last rank were precipitated upon the others by an irresistible force. When the disorder ceased, one unhappy soldier was found to have been struck dead upon the soil, and thirty-three others were more or less burnt by the electric fluid. A circumstance, somewhat curious, deserves to be mentioned, as a proof of the projectile force of the meteor. A sentinel, before whose eyes the above scene occurred, was the only person not knocked down, but he felt himself severely shaken, his musket was wrenched from his hands and, before reaching the ground, was turned over in a very curious manner: it was found deeply sunk into the soil, the muzzle downwards. The sentinel was unable to define accurately the sensations which he had experienced.

XLII.

FALSE JUPITERS.

THE ancients were persuaded that lightning and thunder pertained only to a superior power. To imitate thunder was considered a kind of sacrilege by all religions. One of the most exciting passages in the description of the infernal regions, is that in which Virgil relates the fate of Salmoneus, a prince struck down by Jupiter's thunderbolt, who had incurred this penalty for having imitated the noise of thunder by driving his chariot over a brazen bridge. Dionysius of Halicar-

nassus quotes, in his *Roman Antiquities*, the unhappy fate of one of the ancient sovereigns of Latium, who took it into his head to manufacture artificial lightning.

For centuries one has been shown in the neighbourhood of Albe, a lake where, in times gone by, stood the capital of this impious prince; the town dishonoured by his sacrileges had been swallowed up by the waters, like the cities of the Dead Sea.

One of the most fearful reproaches which Tacitus has addressed to the Emperor Caligula, was that concerning his attempt to manufacture fraudulously the thunder and lightning of the sovereign of men and gods. More ambitious still than Salmoneus, and more culpable, the successor of Tiberius was not content with deafening his subjects by causing them to listen to his inoffensive thunder; this refined tyrant had invented a little machine, calculated to reply to the gods, by throwing a heavy stone towards the sky, whenever lightning happened to strike the earth.

In our days, the imitation of the sound of thunder, or even of the lightning flash, is far from being considered a condemnable pastime; it may be safely asserted that this was not the motive which caused the Roman Church to excommunicate comedians. M. Robin, of Paris, has certainly never been the object of any reproaches, though he gives a representation of lightning every evening, in his Theatre of Physics. M. Dennery and his disciples know how to make thunder, a kind of Jack-of-all-trades, wherewith to get through a number of difficulties; for the noise of thunder generally plays its part very well in some of our modern melodramas. Electricity has more than one recommendation, and can speak both to the ears and to the eyes.

They would have been wrong to neglect this fertile source of emotion, the more so as the artifices employed

are simple and cheap, though science has not yet given to them its latest resources.

Almost every one knows that the illusion is produced by shaking, behind the scenes, a long piece of sheet iron, which does not cost five shillings. The metallic sheet, held delicately between the thumb and first finger, gives birth to the desired peal, when the operator causes his hand to oscillate rapidly from the wrist. This manœuvre, so very simple in itself, is susceptible of a certain degree of perfection. The public have, therefore, a sound which resembles, more or less, that of nature, according as the modern Salmoneus, getting his two shillings a night behind the scenes, is more or less expert in his art. If, instead of being content with this, and similar rudimentary processes, all the resources of the art of M. Ruhmkorff were called into action, some marvellous effects might certainly be produced.

XLIII.

LIGHTNING AS A PHOTOGRAPHER.

OFTENTIMES the bodies of persons struck by lightning have been found coloured with very vivid tints: this species of tattooing offers a great variety of forms, varieties, and tints; it is found upon every part of the body. Certain authors have observed scars of a blue colour, others nearly black; and others, again, of a fine vermilion. The curious marks are produced by a multitude of burns or scars, combined in various manners: moreover, it is not only on dead bodies that they are remarked. Men have sometimes escaped the lightning, says some great poet, but they remained marked with the seal of its mysterious power.

The atmospheric spark sometimes acts upon the blood

and decomposes it, even in the finest ramifications of the little veins or arteries; the parts thus struck appear, then, as if they had been injected by the most clever anatomist. Father Beccaria, who first called attention to these strange infiltrations, could have invented, without difficulty, the processes used in our anatomical museums to put in evidence the vascular nature of various tissues, if that art had not been already known. For lightning acts with enough delicacy to render M. Auzou or M. Gannal jealous of the preparations which leave its mysterious hand.

But when the spark eats into the tissue of the skin, it produces the most curious mutilations.

On the 14th of June, 1794, lightning entered a hut where a peasant family was assembled. Three children were struck down with much violence. Judge of the surprise and alarm of the parents when, on raising the poor children, they appeared exactly as if they had caught the smallpox in an instant! Their cheeks when they fell were simply rosy, but when lifted up it was seen that they had become dreadfully mottled.

When these lenticular blotches are found under the clothes, it would seem as if little grains pushed by an invincible force had penetrated the linen, the silk, or the cloth. The marvellous grains appear to have passed through the clothes without injuring them, for no corresponding holes are discovered. Sometimes these remarkable wounds are deep enough to be compared to those produced by shot from a gun. They are very numerous, for on one person affected in this manner there could be counted no less than two hundred marks. At other times the marks are so small that the skin is covered with them, and appears as if it had been burnt with very fine hot sand. An accident of this nature happened to a man who, not content with having taken refuge under a tree during a violent storm, was leaning with his elbow against

a knob upon the trunk. When the tree was struck, a cloud of microscopic splinters appears to have bombarded his elbow from the excrescence against which it pressed.

Professor Gerdy had occasion to examine, at the Morgue of Paris, the body of a man killed by lightning, which had struck his head; it appeared exactly as if he had been killed by a gun charged with very large shot.

When one of the victims of a thunderbolt which fell at Everdon, as we shall see presently, was being undressed, the unfortunate individual was seen to have upon his body a hole the width of a goose's quill. This species of fistula, which corresponded with the region of the abdomen, was internally black, dry, and hard, presenting evident marks of the action of fire.

Here we have a tube resembling the fulgurites, those long vitrified tubes found in the sand, with the sole difference that it had been pierced in the body of a living organism.

Sometimes the curious marks of which we speak resemble those produced by a cane or a rod; flagellations similar to those which excite the admiration of lunatics. Howard describes such marks upon a child whose breast was torn as if by the violent stroke of a whip. Serno quotes the example of a young man whose feet were wounded as if he had received upon them several sharp strokes with a cane; and a young woman of whom Oswald speaks, appeared to have been thrashed on the back.

These electric wounds have sometimes a hard, abrupt aspect. Orlando Bridgeman relates that a man thus flagellated by lightning appeared as if he had been flogged with rods of iron.

What millions of dupes certain charlatans might have made in showing about such extraordinary wounds! It would not have required much exercise of imagina-

tion for Dr. Brillouet to place at his feet a multitude of ignorant beings, and to make them believe that he had been the object of a miracle; for the traces of an electric beating which this gentleman had received appeared to have some mysterious connexion with the electric spark: whenever he lit up his room the marks took a fine red colour.[1]

One of the most astonishing results of lightning physics is the production on the surface of the body of certain strange drawings, something similar to the lines known as the *figures of Lichtenberg*. It has been sometimes remarked, without our being able to assign a motive for these marvellous actions, that lightning traces on the skin of its victims certain images similar to those with which a professor of natural philosophy amuses his pupils.

Imagine some primitive lines of curious form, the first of them straight as if ruled, the next irregular and sinuous; whilst two or three streaks of the same nature appear to form a tissue of parallel lines on the surface of the skin. In another case, a multitude of lines blending one into the other, crossing each other again and again in every possible direction, will be perceived. These lines give rise to figures of stars, pincers, bouquets of flowers, &c., sometimes sketched with wonderful delicacy. In fact, they might at times serve as patterns for shawls, cashmeres, or embroidered silks!

Shall we admit that these streaks correspond to parts that have been overloaded with electricity, which has thus playfully escaped in invisible radiations?

Shall we admit that the electric fluid has dispersed itself under the influence of some unknown attraction,

[1] This was merely an effect of contrast, and is likewise observed with our mauve dyes, which appear red in the evening by the gas-light. The bluish colouring matter of venous blood appears to possess similar properties. (Translator's note.)

of some harmony which has hitherto escaped scientific observation?

When Pliny the younger tells us gravely that the son of Marcia, a Roman lady, was struck by lightning which did no harm to his mother, we might shrug our shoulders. Nothing would prevent our laughing quite as heartily at the reverse phenomenon described in Ovid's "Metamorphoses;" Bacchus escaping, as we have seen, whilst his mother Semele is burnt. And why?

But no one will hesitate to condemn the credulity of that Latin author, who relates that a thunderbolt changed the sex of a child; that an unfortunate boy was suddenly transformed, by Jupiter, into a little girl! More than once an observing mind remains in anxious suspense before the marvels of electricity. The route is arduous and difficult to keep when travelling betwixt the Charybdis of doubt and the Scylla of credulity. Who, then, has a right to forget that the theory of magnetism and electricity entirely reposes on facts which for thousands of years passed as fabulous? For, as Hamlet says, there are more things in heaven and earth than are dreamt of in our philosophy.

XLIV.

KERAUNOGRAPHY.

ACCOUNTS published in certain journals before the discovery of Daguerre, mention strange phenomena which might have suggested the wonderful invention of photography. Witnesses who appear worthy of confidence have seen the shadow of an individual struck by lightning fixed spontaneously upon a wall. Some observers, doubtless as truthful, perceived the image of a tree traced upon the breast of Pitcairn by the lightning which struck him.

One day in September 1825, lightning smote the brig *Buon Servo*, at anchor in the Bay of Alnuro, at the entrance of the Adriatic. A sailor sitting upon a box at the foot of the foremast was repairing his shirt. The unfortunate man was struck by the electric fluid attracted—who knows?—by his needle, perhaps. On undressing the body, they saw a long dark line, of very slight width, extending from the neck to the small of the back, where the image of a horse-shoe was distinctly visible. It appeared as if tattooed, and was the exact representation of a horse-shoe nailed to the foremast of the ship, according to a superstitious habit of the sailors in the Archipelago, to keep away "bad spirits."

Another sailor struck down in the same manner, had upon his breast the name of the ship very distinctly marked.

Arago relates in his *Notice sur le Tonnerre* the story of a man who was near a tree which was struck by lightning. Although much frightened, no actual harm happened to him; but in the evening, when going to bed, he saw with terror that he had been marked with the seal of the thunderbolt. The incomprehensible fluid had impressed upon his skin an image of the tree with all its branches.

Reason, you will say, revolts against such tales, which should only figure alongside of "Tom Thumb," "Peau d'Ane," or "Beauty and the Beast." Stop! Do not let us make such a noisy profession of incredulity. In fact, we can realize in the laboratory certain phenomena which are closely analogous to these strange productions of Keraunography, without having recourse to any magical incantation. We can direct, up to a certain limit, the emanations of voltaic electricity. Is any one disposed to believe that nature can be less powerful?

In 1796 a thunderbolt fell on the church of Lagny,

and struck the altar, attracted no doubt by the ornaments of gold and silver which the faithful had accumulated there. On exploring the site of the disaster, it was noticed that a phenomenon quite as astonishing as those of the witches' Sabbath had occurred. The text of the lessons for the day had been transported upon the cloth of the altar with reversed characters, exactly as the thing is recommended to be done in treatises on black magic. How did this marvel occur? The verses which the priest was to have read were printed in red characters, somewhat of a conducting nature, and upon a cardboard which the explosion had overturned upon the cloth. The ink had quitted the cardboard to stain the linen, by the simple influence of the electric current and not by any infernal agency. It is thus that, in our youth, we were taught how to obtain the image of Franklin upon a colourless silk ribbon by means of a piece of gold leaf!

May we believe that a similar kind of transport can take place at a certain distance, in such a manner that each ramified flash of the thunderbolt tears from a tree a portion of its substance destined to imprint itself upon the skin of a spectator standing near? What invisible lens causes such rays of lightning to condense themselves so as to give an image an inch long of an object whose dimensions are some twenty or thirty yards?

Let us leave to future centuries the task of unveiling this mystery, which contains perhaps the germ of a future revolution in optics; many discoveries have a no less fantastical origin. Let us limit ourselves with placing the facts themselves beyond the sphere of incredulity, by mentioning two cases of keraunography which appear to be perfectly authentic.

The *Comptes-rendus* of the Academy of Sciences at Paris, affirm that the image of a poplar leaf was found upon the body of a magistrate and upon that of a mil-

Coast-Guard blinded by Lightning. 219

ler's boy, who were both struck by lightning at the same time and by the same flash. This occurred in 1841, in a village of the Departement de l'Isere.

In its issue of the 26th August, 1866, the journal *Cosmos* of Paris gives an account of a thunderbolt which fell on the preceding 27th of June at Bergheim, a village situated at the foot of the Vosges mountains. The meteor struck a linden-tree under which two travellers had taken refuge, and the shock was so violent that both were rendered insensible. When they were being undressed, in order to reanimate them, it was observed that both victims presented certain strange markings on various parts of their bodies. These marks were the images of the leaves of the linden-tree, designed as faithfully as if executed by the most expert artist, says one of the eye-witnesses.[1]

XLV.

LIGHTNING AT A DISTANCE.

In the month of May 1866, a Custom-house officer was going his round upon one of the northern coasts. Suddenly a flash of lightning struck a rock in the neighbourhood. The unfortunate man was instantly enveloped in darkness. He was absolutely blinded, and could not take a step without danger of falling through some gap in the rocks. Luckily, his shouts

[1] M. Andréas Poey, the young and indefatigable director of the Observatory of Havana, to whom we owe so many interesting observations on lightning, shooting stars, &c., has collected no less than twenty-four very distinct cases of these curious impressions left by lightning; his little treatise was published in 1861 (Paris: Leiber), and in the same year we ourselves published in one of our popular periodicals a paper on "Lightning Prints," where the most curious observations of Orioli, Dr. Boudin, Baron d'Hombres Fir-

attracted some of his comrades, who led him back to the guard-house.

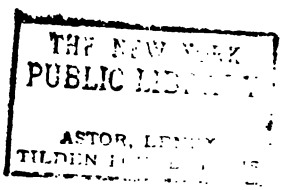
At first this deplorable accident does not appear to merit particular attention from physicists. Must not this blindness be attributed simply to the great heat developed by the electric discharge? The eyes of the unfortunate man appeared burnt, as if he had passed through a fire.

But blindness produced by lightning is not generally incurable or chronic, like that which would be produced by the application of a red-hot iron, for instance. In fact, the insensibility of the retina affected by the passage of the electric current does not result from actual disorganization, but from a species of temporary paralysis. It is, therefore, quite possible that in course of time the nervous perturbation experienced by the unfortunate coast-guard officer quoted above may disappear. There exist nevertheless, cases of permanent blindness.

No one dreams of being surprised at the fact that the sun lights up our dwellings, though it is situated at

mas, and Professor Andréas Poey were brought forward. The subject will be treated of again, in a more complete form, in a work now preparing for publication. Since that year a considerable number of new observations have been made. Quite recently two boys were struck by lightning under a tree near Manchester, and were more or less stunned by the force of the shock. The electric fluid seems to have struck the tree in a *spiral form*, similar to that alluded to in a former chapter of the present work; one of the boys, named Edwards, who was most seriously shaken, presented on his left side a perfect image of the tree, leaves, and branches represented with photographic accuracy. Professor Tomlinson, remarking on this case, says, "It would be easy to show that these ramified figures are sometimes produced on the bodies of men and animals when no tree is near." However, the learned professor does *not* show us anything of the kind. It is only by collecting numerous facts, and submitting them to careful investigation, as M. Andréas Poey has done in so praiseworthy a manner, that the true explanation of these curious images will some day be discovered. [Translator's note.]

Effect of a distant Thunderbolt. 223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some ninety millions of miles' distance. Until lately, no one objected to the theory, which assumes that attraction is manifested at infinite distances. Are not our most scrupulous astronomers disposed to assert, on their scientific honour, that the stars themselves are subject to the laws of Newton? But many people will refuse to admit the fact, when it is asserted that these effects produced by lightning at a distance of some yards are attributable to laws of electric action.

We will certainly not imitate the ancients, who attributed to thunder and lightning various functions in the Olympia. We will not say with Plutarch, that it causes truffles and mushrooms to grow (we are not quite sure as regards mushrooms), but we may fearlessly remark that every vortex of electrical matter is a centre of radiating emissions; for, acting by molecular induction, electricity may extend its effects further and further, until its sphere of action is as wide as that of light itself. Who knows but what the propagation of electric undulations examined so ingeniously by Faraday, does not conceal the solution of many optical problems?

In any case these mysterious currents may be considered as the seat of forces which penetrate all bodies, not excepting our own, which act upon the substance proper of our sensations, if we may so express ourselves. Our reason and our intelligence are not exempt from their influence, and—must we say it?—our moral liberty appears sometimes affected by the proximity of accessible lightning.

Ophthalmia is so frequent among the clerks of tele graph offices, that the *Annales d' Hygiène* has published instructions regarding them. The currents which travel incessantly along the wires have not the power of manifesting themselves one by one, but in succession they produce a weakness of sight similar to that of which

sailors on the yards of ships complain. Still more exposed, doubtless, than the clerks of the telegraph stations, sailors on watch are a butt to thunderbolts. These unfortunate individuals are often struck in detail, for their bodies are traversed by a multitude of currents which, though invisible, are nevertheless extremely active, and their number is legion.

Is it not from having remarked these distinct effects of atmospheric electricity, that astrologers have compared the human being to a magnet having two poles, two separate fluids, the two principles of Manes,—one side angel, the other side beast?

However that may be, the golden globes which people the ethereal ocean are constantly charged with dynamic electricity. They are the centres of a constant radiation of vivifying force. When the sun is over the Atlantic, it troubles, apparently, the working of the great cable. The telegraph which winds along in the depths of the ocean, appears then to stammer out incomprehensible messages.

Must we not admit, then, that beings charged with that still more subtle essence called life, are much more subject to the action of celestial movements? Dare we entertain the opinion that they are not governed by that divine harmony which, according to Kepler, fills all space; that they do not hear that sublime voice which chants eternally the glory of the eternal and infinite Being?

What questions arise when we endeavour to analyze the perturbations which we, poor trembling little compass-needles, experience each time that the heavens exchange before our eyes a long kiss of flame! For our oscillations are between crime and virtue, not betwixt north and south. Is not conscience the pivot around which our intelligence oscillates? Was that enthusiast Kircher right, by accident, when he exclaimed

hat the whole secret of Nature may be contained in a ingle flash of lightning?

XLVI.

CAPTIVE LIGHTNING.

THE parish of Chisey, in the Département de l'Indre, is crossed by a highway bordered by two rows of walnut-trees. A telegraphic wire, supported by posts, runs along one side of the road, and approaches nowhere very near to the trees which ornament it,—at least, not within some four yards of them.

On the 29th of May, 1861, lightning, which, like poets, appears to have a special affection for cool shady spots, fell upon one of the walnut-trees. The tree chosen by the meteor stood near a pond, at a little distance from a house, the roof of which, covered with sheets of zinc, perhaps determined the explosion.

The electric fluid penetrated the interior of the walnut-tree, which appeared to offer an easy route to it, and it produced, apparently, no further effect. But a portion of the electric torrent, as often happens in similar cases of fulguration, sprang to the telegraphic wire, which was consequently broken in several places.

This accident was not the only trace of the passage of the electric current, for it was afterwards discovered that the trunks of about thirty of these trees were marked by a longitudinal groove, extending downwards from a height corresponding to that of the telegraph wire. One would have supposed that a red-hot iron had been passed down each of the trunks.

Those who have endeavoured to volatilize or to melt small pieces of metal by means of the voltaic current, can form some idea of the immense quantity of elec-

tricity which must have passed from the telegraph wire to produce such an effect at several yards' distance. They know, in fact, that the operator must call into action a very powerful apparatus, in order to obtain at a certain point a miserable spark some inches long.

The dynamical state of the wire brought about by the lightning was infinitely more intense. It manifested itself by radiation over a distance of more than a hundred yards, and, even in these circumstances, was sufficient to occasion the combustion of the living bark of the trees!

The investigation of phenomena produced at a distance where lightning is confined to the rod of a lightning-conductor, might furnish us with several effects of the same kind. We might complete the demonstration begun in the preceding pages, but what appears of more consequence is to show that the terrible fluid appears to have lost all its dangerous power when imprisoned in an iron rod.

Thus, the three lightning-conductors with which the prison of Charleston was provided, were not sufficient to prevent the place being struck by lightning on the 31st of July, 1829. Three hundred prisoners locked up there were more or less affected by the discharge. Each one felt a violent shock, a sort of instantaneous insensibility; however, none of them were killed, nor seriously harmed.

A similar thing happened to the workmen in the shop of a tinman at Strasburg, near the cathedral. They saw great flames issue from the floor of the shop the moment the tower of the cathedral was struck by a vivid flash of lightning, but they experienced no disagreeable effects.

The soldiers knocked down by a thunderbolt which struck the barracks of St. Eugène, at Paris, a few years

ago, were also able to congratulate themselves on the clemency of the lightning.

Let us add, however, that in these three observations the captive lightning was seen to manifest itself externally. The tinkers of Strasburg, who saw the electric fire play innocently around them, had in their hands large sheets of iron at that precise moment. The chronicle says, moreover, that the back of the shop was full of old iron.

The soldiers in the barracks of St. Eugène would not have been so severely shaken had they not had their muskets in their hands; but they were about to relieve guard.

Suppose they had been reposing on the camp beds in the interior of the barracks when the meteor struck, they would certainly not have perceived the electric current which flowed along the lightning-conductors destined to protect those barracks from the fire of the storm.

Can we believe that the prisoners at Charleston would have felt so violent a shock if their prison had not contained so large an amount of iron? After the occurrence, people were less surprised at the singular effects noted, when they discovered that there were more than 200,000 pounds weight of iron spread over a surface of only five acres, in the shape of gates, railings, chains, bars, and tools of every description.

A detail extremely interesting in itself enables us to appreciate with what facility the human organism bears the effects of very energetic currents of electricity, when it is only exposed to those of captive lightning at a distance. The blade of a saw in the hands of a mechanic appeared to become suddenly red-hot under the influence of the vortex of electricity circulating along the lightning-conductors.

If it were not making use of an exaggerated metaphor, might we not say that captive lightning resembles a muzzled lion with his claws cut?

XLVII.

OF COMPLEMENTARY DISCHARGES.

On the 16th of July, 1866, one of the most violent storms on record burst over Paris about one o'clock. The clouds, which came rapidly from a southerly direction, accumulated in a fearful manner. In a few minutes the whole city was plunged in darkness.

The rain fell so abundantly that it is difficult to give a description of it, and with such rapidity that, in spite of the perfection of the subterraneous outlets, the streets were soon transformed into gurgling streams. The drainage was so promptly invaded that several workmen were not able to gain their ladders in time, and were drowned by the rushing waters.

During the few hours which this tempest lasted, the lightning struck several places, and gave rise to a number of curious and interesting observations. The air was filled with fawn-coloured reflections, and dull sounds of a startling character, which indicated how prodigious was the tension of the electric elements.

We saw flames rise from the earth in places where the rain struck the pavement with great force. It appeared as if the fire started from the stone on receiving the shock of the water. It was in the Rue de Rivoli, along the footpath which joins the Palais des Tuileries, that this extraordinary effect was seen to greatest advantage.

Curved lightning, shaped somewhat like a V, precipitated itself towards the point with intense rapidity.

The *quartier Latin* was assailed in a most singular fashion, as if the storm were directed more particularly against the hill of Sainte-Geneviève. In fact, lightning struck in four distinct points of the students' quarter; first the hospital of Val-de-Grâce, at about two o'clock; a little later, the Ecole de Droit; a few instants afterwards, No. 4, Rue des Ursulines; and lastly, about half-past three, the Ecole des Mines. The details which we collected at these various places, will, we hope, give some idea of the force of this dreadful tempest.

The flash which struck the Ecole des Mines appears to have been the most terrible, as it was accompanied by several violent lateral discharges. M. Colon observed, in the Luxembourg gardens, an orange-tree, the wooden case of which was broken in eight different places. Although the lightning did not strike this tree directly, it covered it with mud, transported, as often occurs, by the electric current upon objects exposed to its influence. At the moment of the explosion, the under-librarian of the Ecole des Mines saw the garden appear as if on fire. At the same instant the librarian, who was turned towards the inside of the room, saw so brilliant a light glare upon the floor that he was obliged to close his eyes. The top of an elderberry-tree in the garden of the Ecole was cut off as if by means of a knife, so neat was the fracture in the parts where the fibres had not been torn.

In these places the ruptures appear to have been of a spiral nature, and are analogous to what mineralogists call conchoidal fracture.

This elderberry-tree is separated from the railing of the Ecole by a species of curtain, consisting of three trees of a resinous nature which surround it. It appears as if this line of isolating trunks had caused a concentration of electricity, a reflux of the electric fluid,

which, thus obliged to return, had produced those mechanical effects alluded to above.

The lightning occasioned a phenomenon in the Rue des Ursulines which has not been uncommon this year in Paris, as we shall see presently. It lighted the gas issuing from a rent which it caused in the leaden pipe which supplied it from the meter. The porter saw at this instant a kind of irregular flame, winding under the *porte-cochère*. It was a portion of the electric matter finding its way to the interior of the earth.

On the contrary, the stationer of the Ecole de Droit saw the heavens as if on fire, the moment that the lightning struck that establishment.

The porter, and all the individuals near, experienced a violent shaking, and their evidence might be brought forward to contradict those who deny the existence of lateral discharges, and who believe that one may live in security alongside of a lightning-conductor.

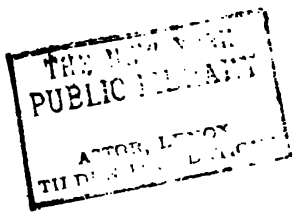
These persons also saw a blade of fire glaring suddenly at a spot where the water-pipe of the house comes to within a few inches of the pavement.

The lightning, which had nevertheless struck the conductor, had then been withdrawn from the chain by one of these iron pipes full of water which are destined to carry to the earth only the liquid residue of storms. Does this not prove that there would be an advantage gained if these pipes were in direct communication with the soil, as we shall have presently an opportunity of explaining?

Flames of electric fire running close along the ground were perceived by a great number of persons. It is therefore impossible to doubt this fact, which many of our physicists will not be able to realize.

A bootseller in the Rue des Cendriers saw a flame issue from the window of her shop, the instant that she heard the report of the explosion, which struck the

Explosion of Gas. 233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house opposite, and demolished a chimney. An individual who had taken refuge under a *porte-cochère*, tells us in the *Opinion Nationale* of the 20th of July, that he was exceedingly astonished to see fire issue from the street pavement. That he was not suffering from an illusion may be inferred from the fact, that the sole of one of his shoes, liberally supplied with nails, was torn away by an invisible force; it was cut suddenly from the shoe, as neatly as could have been done by a knife.

The lightning which struck the washhouse of the Valle-de-Grâce spread itself into several secondary currents, and it is difficult to describe the directions which it took. One branch appears to have caused a hole in a window, and another a hole in the wall some three yards further on. Some of the women who were there pretend that they saw a globe of fire pass along. The principal current followed a leaden pipe, until it entered the washing tank, which contained several cubic yards of water. At this point it exploded, attracted doubtless by the conducting nature of the liquid. It lighted a great jet of gas, and precipitated itself into the water, where it disappeared. The thirty women who were occupied washing the linen of the hospital, remained for some instants in an indescribable state of terror. The most courageous almost fainted. In general all the inmates of this vast establishment were more or less influenced by the phenomenon. For a long time afterwards many believed that they were still electrified; which was, perhaps, only an illusion on their part.

At a moment when the storm growled in all its fury, we took a cab, and drove to the foot of the Colonne de Juillet, thinking that there we should doubtless witness some instructive phenomena. We were not mistaken, for we soon perceived flashes which illuminated the *statue of Liberty* which crowns this fine monument.

The Statue on the Colonne de Juillet electrified (1866.)

These flashes could not be considered as reflections of distant lightning; for they all passed along the spot where the foot of the figure rests upon the ball. At this particular spot their brilliancy was quite dazzling. One of the most remarkable of them emanated from the extremity of the leg which the figure extends into the

another, with surprising brilliancy, descended
1 the hand of the statue which is raised towards the
, and also passed down to the point where the foot
ined to the ball, which represents our globe.

The Weathercock of Notre Dame electrified (1866).

hilst we *made these* observations, certain persons, *own to us, observed* similar phenomena on the

church of Notre Dame, and published their remarks in *La Patrie;* they perceived a number of bluish sparks emitted from the metallic arrow at the summit of the steeple.

Would not this contrast of colours indicate that these two monuments served as the poles of an ordinary circular current, a regular vortex completed by the atmosphere? Did not the inhabitants of Paris on this remarkable 16th of July experience the effects of lateral or complementary discharges? Was not the arrow of the Notre Dame to the statue on the revolutionary monument, what the north pole is to the south pole of the earth?

Without knowing it, the Parisians must have lived for some instants in the plaits of an electro-dynamic curtain; a bright radiating canopy, which covered a considerable portion of old Lutetia.

The terrestrial circuit may have been completed by the mass of water which lies between Notre Dame and the Place de la Bastille. Effectively the Colonne de Juillet is built over a canal which joins the Seine, and the latter, at no great distance, flows past Notre Dame.

Who would be astonished that the electric fire had sprung from one point to the other? Why should it not have manifested itself in two forms, and with two colours as distinctly as in a Geissler's tube a foot long, in a terrestrial machine, which is twenty-four millions of times as large?

An accident which occurred in London, about the end of the same month, again shows that canals conduct electricity with a degree of facility which is favourable to those interesting spectacles. A policeman who was running after some children to prevent their bathing in the Surrey canal, suddenly staggered and fell into the water, doubtless struck down by the effects of the lightning which at that moment fell in the neighbourhood,

and which had killed the unfortunate man without leaving any traces upon his person. The coroner, ignorant of the powerful effects of electricity at a distance, referred this circumstance to apoplexy, which may well have broad shoulders in stormy weather!

XLVIII.

LIGHTNING UNDERGROUND.

We have sometimes heard that the masters of the world took refuge underground in order to escape the effects of the fire of the heavens. Vain and useless precaution, dictated by pusillanimous vanity! In fact, a thousand phenomena prove that the lightning flash is not extinguished even when it meets the common reservoir. Its effects are felt at immense distances. Neither the Cæsars nor the Emperors of Japan could have discovered retreats deep enough to place their royal persons out of danger.

On the 5th of July, 1855, a large number of workmen were occupied in the Mines of Himmelsfurth, as Poggendorff's *Annalen*—that most serious Journal of Physics—relates. As it mostly happens, the labourers were dispersed along a hole of ore, and were little thinking of what might be happening upon the surface of the earth. Suddenly they all received very violent shocks, distributed among them in the most curious and irregular manner. Some of them felt a blow upon the back, whilst their neighbours were struck about the arms or the legs. It appeared as if they were roughly shaken by an invisible, mysterious hand, which at one instant came out of the ground, and at another from the sides or roof of the gallery. One of the miners was thrown with force against the wall. Two others whose backs

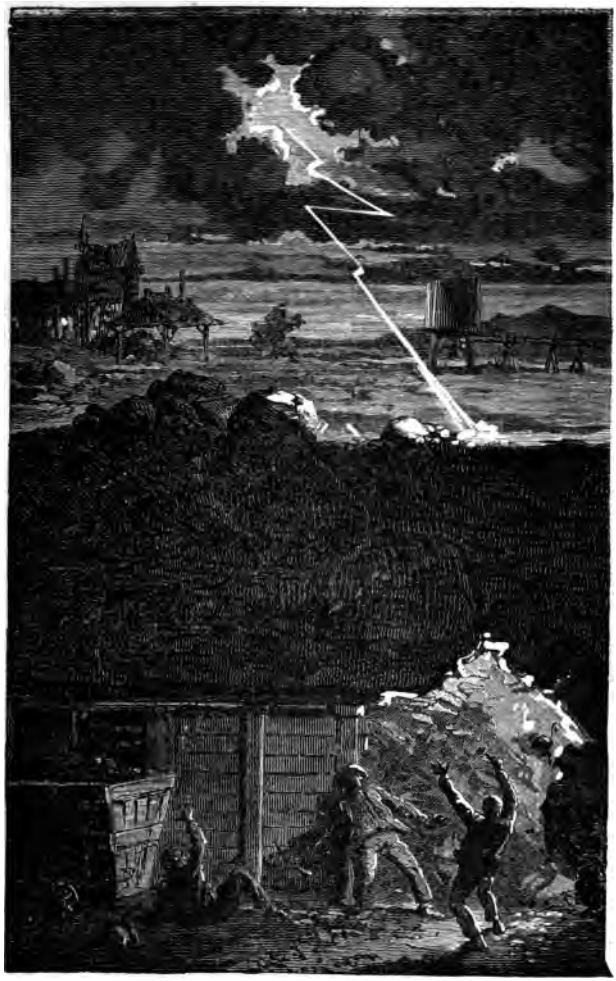
were turned to each other, came suddenly together face to face. Each of these supposed that he had suddenly received a blow from the other in his back. If they had not soon been undeceived, they would have fought it out with their fists on the spot, in this dark pit some 1,000 feet under ground!

An iron-wire rope descends from the mouth of one of the principal Freyberg mines to the level of the lowest gallery, a depth which has become proverbial. It is by means of this conductor that the workmen employed in the mine can exchange signals with the men above, who attend to the machines. A sentinel is therefore always placed near each extremity.

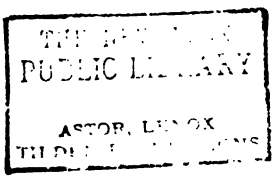
On the 25th of May, 1845, the guard up above saw lightning precipitate itself upon the iron cord, and illuminate everything around. The guard below saw at the same instant, a clear, vivid, and sudden flame emanate from the other extremity of the wire-rope. The light spread over the interior of the mine without afflicting any one with the slightest shock.

Here we have an example of a wire rope some 1,200 or 1,500 feet in length introduced into the circuit of an immense discharge, and, though so immense, this discharge imprisoned by the metallic conductor produced no destructive effect. The storm above had once again penetrated into deep regions, but it had been weakened the whole length of its route; it arrived at the bottom of the mine completely deprived of its power of doing harm, or making its presence known otherwise than by an inoffensive flash.

It is easy to imagine that certain metalliferous lodes exert an electrical influence similar to that of this iron rope at Freyberg. As Arago has very justly remarked, the places where metalliferous lodes crop out at the earth's surface must draw storms towards them sometimes from distances.



Miners struck by Lightning.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The ignorant may imagine that some supernatural influence attracts the storm-clouds; but geologists will seek in the stratification of the earth and the nature of the soil the reason of these singular preferences.

Who knows but that it will some day be discovered that the indications furnished by the study of storms may be considered decisive as regards the exploration of mineral districts? Even at the present day, thunder is perhaps a better guide than the Abbé Paramelle, not only for seeking water, hot springs, and others, but for the systematic discovery of lodes of iron and copper or strata of coal.

XLIX.

VOLTA'S PISTOL.

THE storm of the 4th of April, 1866, was remarkable for the number of thunderbolts which fell upon Paris, and by the absence of serious accidents. To show how very benign the electric fire was upon this occasion, we have had sketched, from the description given by a young workwoman who witnessed it, the passage of lightning down the staircase of a house at Montmartre; the young person met with no harm, but was simply astonished by this sudden appearance of an electric flame.

As the clouds were very low a great number of houses felt the influence of the mass of electricity accumulated over Paris. All the lightning-conductors must have acted to their utmost, and must have withdrawn an incredible quantity of electricity. The gutters on the roofs and the waterpipes must also have conducted an enormous quantity of electric fluid, but in certain localities the proprietors of the houses had, *for the sake of economy*, neglected to place the pipes in

direct communication with the ground. The electric fluid, consequently, sprang from the extremities of these pipes to any metallic or other conducting object that might be near. In three or four cases a leaden gaspipe was the nearest object. A phenomenon then presented itself that was somewhat similar to the experiment made at ordinary lectures, and known as Volta's pistol. The spark having melted the lead, in consequence of the great calorific power which it possesses, a jet of gas was produced and immediately took fire.

The people were in great fright wherever they saw these long flames; and they hastened to flatten the tube to prevent the flame entering it. In the Rue de la Pepinière de Plaisance, where the accident just mentioned occurred, the alarm even caused the people to turn off all their gaslights. This precaution, quite useless and puerile, shows how little is known of electricity even in a civilized capital!

At the Institute the surprise was not less great; it produced a discussion, which unfortunately terminated without any particular result. May we be permitted to add that the fact of the inflammation of gas by the electric spark is quite familiar to our learned men? The machine of Lenoir works upon this very principle; and this apparatus, in spite of its imperfections, has already been applied in several cases, and has become tolerably vulgarized.

Franklin has shown in his letters to Dalibard that the metallic borders which run along houses, such as gutters, &c., to draw off rain-water, attract electricity. This remark actually caused Reimar to construct lightning conductors without a point, which are much used across the Rhine, and are very efficacious. Perhaps they are preferable to those actually in use on our palaces and public buildings.

Lightning passing down a Staircase. 245

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L.

LIGHTNING AND RAILWAYS.

THAT which prevents certain educated physicists from understanding the theory of these phenomena is the difficulty they experience in forming a notion of a natural current. The recollection of the *Vortices* of Descartes troubles the successors of those who believed that they had stifled Cartesianism by heaping upon it ridicule and scorn.

We must admit that things take place in physical experiments and in storms as they do in the practice of electric telegraphy. Whatever be the motor of the vortex of electric matter, the whole quantity put in motion must be considered as identical throughout the entire curve which it describes. Whether it be a circuit, one-half aërial and one-half terrestrial, such as that from Notre Dame to the Bastille, or whether it be an immense circuit which goes from one pole of the earth to the other, the phenomena produced are identical. The quantity of fulgurating matter is not greater in those places where flashes, radiations, or sparks occur; but in these portions of the circuit the electricity passes with difficulty through matter; there result energetic frictions which are called "light," "heat," "electric shock," &c., &c. The struggle between the fluid and the material molecules betrays the passage of the current. It is thus that the water bubbles and roars in those points of a river's bed which are firmly shut in by *some powerful obstacles* on the shores.

The construction of railways ought to have familiar-

ized us, however, with the notion of natural currents, for lightning, which we ourselves have seen circulating along little streams in the streets of Paris, must be more frequently seen precipitating itself on iron rails. In fact, we are often told that railway travellers find themselves enveloped in true electrical vortices. The newspapers of Toulon inform us that a phenomenon, which cannot be explained otherwise than by the above theory, occurred some years ago to a train on the Marseilles line of railway. The passengers appeared to travel in an ocean of flame, so brilliant and so rapid were the flashes of lightning which accompanied them. Nevertheless no one experienced the slightest accident. A learned American, Prof. Henry, has witnessed, we may say, the circulation of the fluid along the rails: effectively, he saw luminous sparks issue from all the joints. This fact, which cannot be of rare occurrence, was observed also on the 21st July, 1841, and in circumstances worthy of note, by a guard on the Malines line of railway. An engine with a few trucks appeared, for an instant, to be one mass of fire; brilliant jets of light emanated from each of its angles. The guard, and some of his comrades who also witnessed this curious phenomenon, had the curiosity to approach the engine, and received violent electric shocks.

It is not always prudent to approach these strange, natural sources, though their effects are generally less to be feared than those which result from the passage of unchained lightning, wandering at hazard through space. Thus, in the month of June, 1846, the electric current imprisoned by the rails was energetic enough to cause the death of a person walking quietly by the side of the railway between Arles and Avignon.

Sometimes men at the points are exposed to shocks, the origin of which they cannot conceive. This happened in May, 1866, to a man who worked at a turn-

plate on a line of railway near Bordeaux. A pointsman at Vésinet also received a violent electric shock in 1847; but, as he heard the explosion, he was not led to believe that he had been played a trick.

Our readers will not be surprised to hear that persons in the vicinity of electric telegraphs are often witnesses of, or victims to, sudden discharges capable of firing a Volta's pistol, or a little fulminating powder. The immunity enjoyed by persons actually upon the rails is not participated in, unfortunately, by those at a little distance from them.

LI.

ANONYMOUS LIGHTNING.

THE fact which occurred to the photographer of Berlin, whilst taking a proof of the statue of the Amazon, must not be considered as unique in the history of lightning; but it must not be believed either, that all cases of anonymous lightning restrict themselves to forming a black streak upon a photographic proof.

On the 29th of May, 1866, the explosion of a manufactory of fireworks occurred at La Villette, and the remembrance of it will terrify for some time to come the inhabitants of Paris. We do not think we are mistaken in attributing this explosion to one of these invisible flashes of lightning.

No cause whatever could be assigned to explain this disaster, if it had not been remarked, that flashes of lightning occurred in the sky precisely at that period, for the establishment in question is reputed for the multiplicity of precautions taken by the workmen who manipulate the various mixtures. Now, the quantity of electricity required to kindle some thousandth of a grain

of the powder used for blasting mines is exceedingly minute. The one-thousandth part of the current which would set the saw-dust on fire in the hands of the workman at Charenton would suffice. May not a current, derived from the rails of the Chemin de Fer du Nord, which lie at a slight distance from the place where this unfortunate establishment stood, have produced the necessary spark, as an effect of induction? Evidently so; if lightning fell anywhere along the line, even at a distance of twelve miles, it might thus cause the death of all the workmen of an establishment so situated.

An Italian physician has shown that a storm cloud, passing at a height of some 2,000 yards over the wires of the electric telegraph, is sufficient to produce very powerful currents along them. Who will not tremble for the safety of powder magazines, on learning that Dr. Henry observed certain steel needles to become magnets from the effects of flashes of lightning, which exploded at more than six leagues from his house?

Since the accident which occurred at La Villette caused a great portion of the Parisian population into distress, a explosion at Woolwich Arsenal was the scene of an explosion equally inexplicable, without having recourse to atmospheric electricity. Moreover, the American papers tell us that an infernal machine (a torpedo, such as the entrance of the port of Charleston during the late war, suddenly exploded. Perhaps there are people who will pretend that some fish touched the machine with his tail, either to spite or to protect the human race. We prefer to believe, however, that invisible electricity managed the business.

Sometimes distant lightning will produce in the open air, as well as at the bottom of mines, shocks of which the cause can only be discovered by careful observation. What a lesson we learn in the following occurrence!

On the 24th of September, 1826, an old man, who

happened to be near a wall in the neighbourhood of Versailles, received a violent shock, the cause of which he could not at first conceive. He learnt a little later, however, that lightning had fallen upon a farmhouse, a mile and a quarter from him, and, at that instant, he was standing over a metallic drain which carried away the waste water of the establishment. Nothing more was required in order that the unfortunate old gentleman should receive a shock violent enough to render him for some time an invalid.

LII.

LIGHTNING AND ELECTRIC TELEGRAPHS.

TELEGRAPHIC lines are provided with lightning-protectors, of very simple construction, which are sufficient to insure the lives of the clerks; for we have not learnt that any home or foreign lines have ever had to deplore the loss of a person employed in their offices. However, this apparatus does not prevent lightning troubling the clerks; for though they have been taught to govern the electric current produced by a Daniell or a Bunsen's battery, they find themselves disarmed in the presence of the slightest storm.

It is some twenty years, perhaps, since Prof. Henry observed the fearful games which atmospheric electricity plays in telegraph offices.

This acute philosopher happened to be in a telegraph office at Philadelphia, when a storm broke over the neighbourhood. How great must have been his surprise, when he perceived that an electric spark shot from the wires each time that it lightened outside! The tempest which growled, and drove along the dark clouds, had an echo in the metallic wires along which fly the thoughts of the moderns.

It is not only clouds in the immediate vicinity of any locality which produce these surprising currents, these explosions which nothing appears to provoke. The telegraph wires would teach us much more, if we knew how to ask them questions, as Lamont and Matteucci have begun to do.

Every one now knows that telegraphic lines are subject to troubles, which are sometimes extensive enough to render their use impossible.

Thus, spontaneous electric currents rendered useless, for four-and-twenty long hours, the cable of the Atlantic Company. This was quite sufficient to occasion a panic, which caused the value of their shares to fall at a prodigious rate. But what valuable lessons would console us for these losses, if we sought to interpret the phenomenon rightly?

As we have already attempted to explain, captive lightning does not produce, in general, accidents at all comparable with those caused by the free and savage lightnings. It seems, as we have said before, that man can to a certain degree accustom himself to live on good terms with the unknown force which envelops us on all sides.

On the 13th of June, 1854, lightning which penetrated the telegraph office of Auch, was powerful enough to burn a part of the dispatch which the clerk held in his hand. However, neither he nor the person who was sending the message received any harm, except that which may have resulted from fright when they both found themselves suddenly knocked down by this invisible power. When lightning broke the telegraph wire in 1845, between Brunswick and Hanover, the clerk was less ill treated than his instrument: when he rose from the ground, where he lay for a short time in a state of insensibility, he perceived that he had escaped

with a very slight paralysis and a swelling on one of his legs.

In 1852, a thunderbolt fell on the railway station at Dijon. Several zigzag flashes traversed the telegraph office. One of them shooting over a distance of about twenty-four inches, struck the eyebrow of the clerk, and caused him to shrink back, but did him no harm.

But would it not be prudent as a rule to set lightning-conductors at a distance, so that we might be out of the way, both of the lightning and of the conductor at the same time? That is what a physicist of the last century proposed, especially in cases of powder magazines. Unfortunately, the height to which it was necessary to carry them, and the expense of elevating these isolated rods, has hitherto caused almost all the architects to hesitate.

Sometimes lightning does not spare those conductors which appear to be arranged in the best manner for avoiding its discharge. The fire of the heavens actually seeks out and finds the copper wire which lies on the bed of the ocean.

If anything menaces the line which joins Valentia to Heart's Content—that *chef d'œuvre* of our century—it is the liability of being volatilized at the bottom of the sea by some current of extraordinary power. Luckily, however, these two stations are upon the same parallel of latitude, and it is generally in the direction of the lines of longitude that torrents of natural electricity move with the most fearful rapidity. If the cable between Algeria and Sardinia has been struck by lightning during a storm, it is doubtless because it happened to be placed in this dangerous direction of which we speak, and for which the spontaneous currents of the globe appear to have a special affection.

LIII.

PECULIAR CASES OF DEATH FROM LIGHTNING.

It has often happened that the bodies of unfortunate people struck by lightning have been violently projected to a considerable distance. Their death has occurred as if they had been the victims of the explosion of a mine. Such marvellous cases of sudden transportation may be generally explained by the instantaneous production of a great mass of vapour as a consequence of the heat developed by the passage of the electric fluid. The phenomenon resembles those of which we have already spoken. Whether it be a piece of wood, as on board the *Patriote*, a piece of rock as in the island of Fetlar, or the body of a man, the explanation is the same. [1]

[1] This explanation is scarcely sufficient; it appears to us far more probable that these curious cases of transportation of heavy bodies to certain distances by the influence of lightning, are owing to the fact that the passage of the thunderbolt creates a sudden and enormous rarefaction of the air, so that bodies are propelled forward with extreme violence towards this partial vacuum. With regard to the production of *vapour* or *mist* by electricity, besides the effect naturally due to sudden rarefaction of damp air, this agent has been shown to have a great influence on the production and preservation of fogs. As early as 1761 Mr. Ronayne, an English experimentalist, drew attention to the electric condition of mists; in recent times, M. Peltier has shown that their very existence depends, to a great extent, on their electrical condition. Perfectly dry air submitted to the influence of electricity in closed tubes is said by Meissner to give rise to a mist over water, which does not disappear on being passed through the water. Moreover, it appears certain that on the electric nature of a fog depends its duration and the possibility of its being condensed by rain. For further details on this subject see my paper "On Electro-Negative, Fogs, &c." *Scientific Review*, February 1, 1867. [Translator's note.]

But such is not always the case. Sometimes lightning produces complete and instantaneous paralysis. The suppression of movement in the victim in these circumstances is so rapid that those who have witnessed it might have thought they suffered from some illusion. Who would not think he was dreaming if he saw an unfortunate creature, full of life and activity, petrified and motionless as a rock, in less time than is required to witness the phenomenon?

Jerome Cardan relates that eight reapers, who were eating their dinner under an oak-tree, were all struck by the same flash of lightning, the explosion of which was heard far away. When some people passing by approached to see what had happened, they found the reapers, to all appearance, continuing their repast.

One still held his glass in his hand, another was in the act of putting a piece of bread into his mouth, a third had his hand in the dish. Death had come upon them suddenly whilst in these positions, when the thunderbolt fell.

Azrael had seized upon them with so much violence that he had impressed upon the entire surface of their bodies the mournful tint of his black wings. One might have taken them for statues sculptured out of black marble!

The catastrophe was so rapid that the faces of the victims had not had time to take any expression of pain.

Life was suppressed so instantaneously that the muscles remained unmoved. The eyes and the mouths were open, as in life, and had not the colour of the skin been so much changed the illusion would have been complete.

It has been remarked also that the features of persons struck by lightning, instead of being contracted, usually assume a calm, happy expression; and the conclusion has been drawn that they enter without shock or pain into the presence of the Infinite Being. It has

even been assumed that death by lightning is the prelude to eternal glory and happiness.

Many persons have doubted the reality of the terrible catastrophe related by Cardan; but a similar fact has since occurred in precisely the same circumstances. Ten reapers who had taken shelter under a hedge, were likewise killed altogether during a violent storm.

Like those mentioned above they had profited by this necessary suspension of labour to enjoy a frugal meal. A touching detail, related by the Rev. Mr. Butler, who narrowly escaped being a victim to the same storm, shows with what rapidity the whole of this joyous group had been deprived of life. One of the unfortunate beings had a dog in his lap at the moment the lightning fell. Whilst he caressed the animal with one hand, with the other he offered it a piece of bread. Both the man and the dog were petrified, as it were, in this position. The paralyzed hand still held the piece of bread, and the expression on the animal's face seemed to say, "Give me some more; come, give me some more!"

Such an instantaneous effect would be incomprehensible were we not aware that the spark of the voltaic battery only lasts for an imperceptible fraction of a second. All would be explained, perhaps, if we admit that death is produced by the neutralization of the electricity which circulates along the nerves.[1] For the little violent current which sustains the activity of the different organs, is absorbed or annihilated. An atom of fulgurating matter suffices to call to it this little trembling flame, which constitutes our vital activity, and

[1] Of late years the learned Professor Matteucci has shown that nerve-force and electricity are not identical, that they travel at different rates, and are two distinct manifestations of Nature's forces. Adopting Grove's views of the correlation of physical forces, we may assume that electricity is transformed into its equivalent of nerve-force when it acts upon the nerves of an animal. [Translator's note.]

develops scarcely any heat. In fact, it has been calculated that the combustion operated in the lungs is not more energetic than that of a single mould candle, such as is used to measure the illuminating quality of gas.

But, the faculty of loving virtue, of soaring towards the infinite, where does it come from? Where does it go? Without doubt, it surpasses electricity itself. If, as the ancients said, we have two souls, lightning can only destroy the inferior one.

To die with the rapidity of lightning is to die as rapidly as thought itself; for the flash which kills so quickly lasts a time as brief as that which but shows us the spokes of the wheel of a locomotive—as that which but enables us to see immoveable in the air the ball which flies through darkness from the cannon's mouth!

LIV.

CURIOUS CASES OF RIGIDITY PRODUCED BY LIGHTNING.

SOMETIMES rigidity of the limbs is produced with fantastic rapidity, of which it is difficult to give an idea without quoting a few examples. The contraction of the muscles in these cases is so powerful, that the victim is instantly changed into a statue, stands upright without any support, and in defiance of all physical laws.

In 1845, four inhabitants of Heiltz-le-Maurupt near to Vitry-le-François took shelter under trees. One of them was unfortunate enough to choose a willow-tree, the situation of which was doubtless extremely dangerous to him. A very short time elapsed before his companions *perceived a bright* flame issue from his clothes. "*You're on fire!* You're on fire! Don't you see you

are burning?' they cried; and as he did not stir, they sprang forward to the place where he stood. Their stupefaction can be more easily imagined than described, when they found that, although standing upright, their comrade was an inanimate corpse!

This extraordinary contraction of the muscles which occurs in the strongest individuals, causes the corpse to remain for an indefinite period in a position which a living being could not retain for more than a few seconds. The wife of a wine-grower of the neighbourhood of Nancy was collecting some wild flowers to make a bouquet, when she was struck by lightning in the midst of her innocent occupation. She was found standing upright, and still holding in her hand the daisy she had just gathered.

Towards the end of the last century, according to the Abbé Richard, the director of an ecclesiastical college at Troyes came home on horseback. He was followed by a colleague who had perceived that he rolled about in his saddle. Thinking he had fallen to sleep as usual, he shook him in order to wake him, as he was frequently obliged to do when they returned together to the college. The director had been struck by lightning during the journey, without his companion perceiving it; and, what appears very extraordinary, no harm had been done to the horse.

M. Boudin, the editor of the *Annales d'Hygiène*, relates a similar anecdote.

A priest on horseback was struck by lightning without being thrown from his saddle. The horse continued his road quietly through the storm. As the unfortunate Abbé was accustomed to ride frequently along the same road, his horse knew it well, and returned home without need of rein or whip. But the traveller was never again to leave the saddle alive; he

had been firmly fixed there by the contraction and rigidity given to his limbs by the lightning.

LV.

MEDICAL EFFECTS OF LIGHTNING.

It is now more than a century since it was first attempted to cure several diseases by means of artificial electricity; it might therefore be imagined that the healing properties of Nature's electric spark had been recognised for many years, for the lightning flash produces in an instant more fire than all the batteries in the world could yield in ten years.

However, Arago appears to apologize to his readers for not ridiculing the pretensions of M. Roulder.

This gentleman dares to pretend—what audacity!—that the thunderbolt of 1835 did good to his general health, although it at first produced temporary paralysis.

The author of the *Notice sur le Tonnerre* has examined during his life-time some thousands of experiments on the physiological effects of interrupted currents; he nevertheless passes with singular rapidity over the fact that certain bonnet-makers pretended they had been cured from illness immediately after a thunderbolt fell on the workshop where they were employed.

It is not so difficult to recognise the unity which characterizes the science of man and that of Nature, so to speak. As soon as ever the academician Du Fay obtained the first electric spark from his cake of resin, it was hinted that this little fugitive flame was *younger sister to atmospheric* lightning.

But the idea that lightning can act upon our feelings or our thoughts, has such grave consequences that Arago could only advance in fear and trembling upon a route encumbered by hypotheses more or less similar to those which adhere to Mesmerism. The subject of an universal fluid is not touched upon without some delicacy, as certain philosophers do not like to hear even its simplest manifestations mentioned.

Lightning, which according to Zoontnyk, fell upon the church of Saint Mark at Roveredo, on the 13th August, 1783, affected the priest who was saying mass. At first it appears of very little interest to note, that after the occurrence—which burnt his dress—this aged ecclesiastic, who had seen some eighty-four summers, was enabled to read without spectacles. But what exaggerated and vain hopes may rise in the imagination of all old people, especially of those who are rich and powerful, on hearing this narrative! Why should they not endeavour to grow young again by taking advantage of the accident which happened to this worthy provincial curate?

What then is this mysterious life-fluid which appears to be so intimately connected with thunder and lightning?

Have we the right to disdain the medical properties of the electric fluid, if it be proved that it possesses the faculty of renovating the most delicate of the organs of sense?

Here again, we have Mr. Gordley, an actor at the Surrey theatre, who recovered the use of his right eye, of which he was entirely deprived. This happy circumstance occurred to him, thanks to a kind flash of lightning, which fell near to the place where he was standing.

Lightning which fell at Biberach, in Prussia, and struck two young people, wounded one severely, but

the other lost deafness, from which he had suffered for many years; magnificent compensation for the suffering he experienced at the time, which was only temporary, and devoid of danger. In fact, it is often found that wounds produced by electricity are cured with marvellous facility, which appears to prove that in its intimate essence, lightning is far from being prejudicial to us.

As a cure for paralysis, a thunderbolt seems to be a sovereign remedy; but the difficulty resides in knowing how to receive a proper dose, and not an exorbitant allowance of it.

An American suffered paralysis upon one side of his body from childhood. A thunderbolt cured him entirely, and gave him the use of all his organs, after shaking him so severely, however, that he remained insensible for about twenty minutes.

An Englishman, who for twenty long years had taken ferruginous baths during the summer, but without any benefit, was entirely cured in less than a second by a flash of lightning. The same story is related of an invalid in one of the Austrian hospitals: being lucky enough one day to stand in the way of the atmospheric spark, he was enabled without delay to leave the establishment, and resume his work.

Scoresby mentions a similar fact which occurred to a passenger on the now celebrated packet-boat *New York*, already alluded to more than once in these pages. Like the American just quoted, this person, favoured by lightning, was paralyzed for many years. He was so astonished at finding himself suddenly cured, that for some time he ran about the deck like a madman. The other passengers believed that he had lost his senses. However, they soon learned what had happened, and admired the unknown mysterious influence which had produced so marvellous an effect.

Suzanne Schmacht was an old maiden lady, so completely paralyzed since her childhood that she could never move a step without the aid of crutches. One day when alone in her chamber she heard a most violent clap of thunder. Much alarmed, she fell upon her knees to implore protection from the Almighty. At this moment she heard a knock at her door; it was her brother who wished to see her. She recognized his voice, and immediately looked round for her crutches. Not finding them at once she prepared to crawl towards the door—her only means of progression when the crutches were not at hand. The fright, the shock her system had just before received, had performed a marvellous cure! Who knows but what natural electricity will be one day utilized medically in the neighbourhood of our lightning-conductors? The marvels we have already exhibited, and those which still remain to be mentioned, are far from proving that any faith must be attached to the dreams of visionaries, but they are still further from demonstrating that it is possible to draw any limits to the power of lightning.

LVI.

CHEMICAL EFFECTS OF LIGHTNING ON LIVING BEINGS.

THE passage of the atmospheric flash from one body to another produces a vast number of chemical effects, which may be compared to those realized on a smaller scale by the electricity from an ordinary voltaic battery: we obtain thus oxidations and reductions, antagonistic and contrary operations, which are realized with equal facility by the marvellous fluid. Why should we doubt the power of electricity in the hands of nature, when in our own hands the multiplicity of its effects is

no less extraordinary? The eudiometer does and undoes chemical combinations with as much ease in one case as in the other. The flash which will reduce a rod of iron to dust, delicately bleaches a solution of indigo, as a writer in Poggendorff's *Annalen* had no difficulty in proving.

Is it not, above all, when the electric spark acts upon animal matters, so complex in their nature and so easily decomposed, that we are capable of judging how various and how incredible are the phenomena which it develops? What becomes of blood, for instance, in presence of atmospheric electricity? Do you think it can remain intact, when we know that this liquid is decomposed by the presence of ordinary inert oxygen, without the aid of either heat or electricity? Can we be astonished that the veins and arteries of the subjects dissected by Gaents, Ebell, Mayer, Gabrielle, and Michelet, were found full of a black adhesive liquid?

Sometimes it is the saliva which takes a strange appearance, and seems quite decomposed. Thus, after suffering from a commotion by lightning in the Monastery of Sainte-Marie les Anges at Faenza, the Abbé Secondini perceived that his teeth and gums were coated with a bitter deposit. At others, we find that some of the humours are decomposed, and give birth to purulent affections.

Dr. Brillouet noticed blisters and tumours covering the whole of his body, and giving rise to so offensive an odour, that for some time he could not enjoy the society of his most intimate friends. Dr. Gaultier de Claubry noticed precisely the same thing on the person of a woman struck by lightning in the neighbourhood of Blois.

Not only can lightning poison a person instantaneously, but the phenomenon can be effected from a certain distance. It does not appear that Dr. Gaultier de

Claubry had been touched by the thunderbolt which fell during a storm in May of the year II. of the French Republic, though he experienced immediately afterwards all the effects noticed in the woman from Blois, and in his colleague Brillouet.

Moreover, lightning appears to have the power of suppressing more or less vital force; it seems as if it destroyed the invisible chain which unites the molecules of an organism and enables them to resist external physical forces which tend to destroy life. The distension of the abdomen and intestines by gas, which is suddenly developed after an individual has been struck by lightning, and is even noticed occasionally upon victims still living, is a proof of the extraordinary energy of this disorganizing power. During the post-mortem examination of a young man killed by lightning, the surgeon observed that the inflated intestines suddenly protruded with much force the moment that the section of the abdominal envelope was effected. Krels mentions the case of a young woman who, in similar circumstances, almost exploded like a bomb-shell, so intense was the evolution of gas.

But this species of meteorization is only one of the forms which characterize the rapid return of an organism to the inorganic state when lightning kills so profoundly, when it takes away not only intelligence or spiritual life, but also deprives the organism of all local vegetative life.

Seneca had long ago noticed how rapidly putrefaction ensues in the bodies of animals killed by lightning, and, in more modern times, Franklin relates a very remarkable case of rapid corruption. Almost all the sheep of a flock which had taken shelter under some trees were killed by the electric fluid; but the next day when the owner sent certain persons to take their skins, the latter

were unable to execute the order, so intense was the putrid odour which emanated from their bodies.

In the month of August, 1809, three lads were killed by lightning near Sedan; it is said that before there was time to bury them the bodies of the little victims had become almost liquid.

When the unfortunate Professor Richmann, of St. Petersburg, was killed on the 6th of August, 1753, by the spark from a species of lightning-conductor which he had erected from his house for the purpose of studying atmospheric electricity, his friends observed that it was necessary to order his funeral with the shortest possible delay.

A few years later, on the 25th of June, 1794, lightning struck a lady in a ball-room at Fribourg, and very similar phenomena of most rapid disorganization and decomposition were observed.

LVII.

LIGHTNING AND THE MICROCOSM.

We know with great certainty, and by the aid of thousands of experiments, that the human body is an excellent conductor of the electric fluid. Experience has proved, moreover, that of the multitude of substances which compose this complicated organism, so marvellous in every detail, none are endowed with a conductibility at all comparable to that of the nerves, none is the source of so much activity as the cerebral substance from which the nerves emanate.

From an electrical point of view we might perhaps compare these white filaments, which are regularly distributed through the flesh of our bodies, to the metallic *lodes which penetrate* the various stratified layers of

the earth's crust. They constitute so many routes traced out for the current beforehand, and along which it will flow in preference to any other, whether it be produced by abrupt discharges of lightning, or simply from invisible oscillations in the electric state of the air, or of external objects.

If the primary currents are weak and distant, their effects may be considered unimportant. They give rise to a species of uneasiness, of nervous excitement, or depression. Mistaken as to the origin of these sensations, we generally look upon them as the consequences of the thousand and one little miseries of this life. We do not dream that electricity has anything to do with our behaviour, or with our ridiculous fits of temper.

If thunder growls in the distance, the effects mentioned will be more noticeable, more precise in their nature. Who knows but that we may become a prey to convulsions? Who knows that we shall not be reduced to dust, and dispersed by a power which has no limits, which nothing appears to control, which seems to hover above us, beyond the limits of our feeble intelligence?

Blind and senseless are those who believe they have only to struggle against cold and heat, against dry and damp! Electricity, too long forgotten, will soon take its proper rank in our treatises on Hygiene. Who knows that it is not fated to belie, up to a certain point, the doctrine of moral liberty?

An officer in the Belgian army, who adopted the doctrines of Cornuol, has doubtless exaggerated the importance of atmospheric electricity in this world. Nevertheless, when a heavy cloud, charged with thunder, rolls over a capital, seventeen hundred thousand brains are oppressed by the same kind of stupor, and await anxiously a common deliverance. When the lightning flashes across the sky, seventeen hundred thousand

consumptive creatures breathe freely the beneficial oxygen of the atmosphere, and everything looks brighter, younger, more amiable, and better.

Lucky is the man who seizes upon this particular moment, when lightning and thunder have just spoken in the air, to ask for what he so ardently desires!—Black cloud, that appearest so threatening, come hither; I fear not the fire thou bearest in thy dark sides; may be, with the flame thou containest a pardon for past injuries!

But what appears so marvellous among the properties of lightning, is its diversity. We cannot sufficiently admire this extraordinary faculty, which permits it to be everything to everybody.

How can we despise a force which we see producing, with the same ease, the most contradictory effects? Does it not appear quite independent, as we have already said several times, of the ordinary laws of Nature, this flame, which in passing through the same eudiometer, will at one time unite oxygen and nitrogen, and at another destroy the combination of these two gases and separate them?

However, if electricity blows hot and cold in this manner, there is nothing capricious about it, nothing arbitrary or miraculous in the wonders which accompany its manifestations.

Two men rush one towards the other, they draw their swords, with violent contraction of the muscles. One of them feels himself completely paralyzed, the other imagines that some invisible god is fighting with him, for he feels unusually vigorous.

Whence this difference? May it not be attributable to an electric current, which in passing through the air has produced by induction, in the two individuals, effects of a contrary nature? It may be that the honour of the victory belongs to lightning!

A servant girl, mentioned by Felstrone, apparently impelled by a convulsive movement, precipitated herself through a window. As she did not injure herself in the fall, she was perfectly surprised at what she had done. Those who had witnessed the proceeding knew much more about it than she did. In fact, her muscles were at that moment the slaves of electricity.

A case cited by Ludwig is still more extraordinary. Another servant stood accidentally near to an electrical machine, and received a shock. For the space of twenty minutes she was seen to run up and down stairs as if deprived of reason. At last she fell unconscious to the ground, and when she arose her memory was entirely gone. Under the influence of the force which had taken possession of her being, the essential motor of will had abandoned her. Some time elapsed before she recovered possession of her senses. When one is driven in such a manner from reason, it is not so easy to return to it again.

The Abbé Chabrol has quoted somewhere the case of a workman, whom lightning transformed into a somnambulist awake, absorbing his reason, and confounding, for a time, his intelligence. When he recovered, he found himself in another person's house, but he could not say why he came there, nor what it was that induced him to leave his own, as he had nothing to do at his neighbour's.

Sometimes electrical hallucinations take a distinct form, and cause us to believe that electricity can render men visionaries. A woman, who had been wounded by lightning, screamed loudly whenever any one entered her house, imagining that it was a demon who came to take her to the infernal regions.

It appears tolerably certain that electricity is capable of producing the most various effects upon the mind. Four men, who had taken shelter in a barn, saw light-

ning strike at some forty paces from them. All four were seized with great fright, but three of them preserved their reason. The other became a raving maniac. He stooped and rose, incessantly shouting at the top of his voice, "But lightning covers the earth! stoop down and pick it up! there is enough to fill many baskets!"

Scheutzer relates, that lightning which fell upon three boys, deprived one of them of reason. He rushed into a church during divine service, shouting loudly that he had come to fetch his head, which a thunderbolt had just torn from his shoulders.[1]

The ancients looked upon maniacs as passive instruments of Divine will; that is why they listened to everything they said; it is in virtue of the same principle that some of our old women believe that it is going to be wet when a cat scratches its ear, or when a frog mounts a little ladder, and think themselves quite as expert as the astronomers of the Imperial Observatory, or the members of the Meteorological Office of the Board of Trade, in foretelling the state of the weather.

It is, in fact, by invalids, weak or sickly persons, that the influence of changes in the weather is most keenly felt. When the *ignis fatuus* sparkles wildly in the grave-yards, remorse and regrets are more vivid; Hamlet sees the ghost of his father; Macbeth is pursued by the spectre of Banquo.

But sometimes the electric current produces dreadful

1 We cannot agree with the author in attributing these nervous affections to the direct action of electricity. Any violent emotion, quite independent of electrical manifestation, is liable to give rise to temporary or permanent loss of reason, and to phenomena similar to those described above. It is easy indeed, in the present imperfect state of science, to invoke electricity as the immediate cause of a multitude of more or less inexplicable phenomena which surround us in this world, but it is another thing to bring forward any substantial *proof of its direct* influence. [Translator's note.]

delirium, especially in the strongest and most courageous individuals.

A sailor on board *La Medée* remained more than a quarter of an hour in a profound stupor after being struck by lightning, which wounded him severely. As soon as he recovered he cast a fearful look around, and endeavoured to escape from his bed, in which it was necessary to retain him by force. Then began tears and lamentations, accompanied by nervous convulsions in every part of his body. He called loudly upon the Virgin Mary to help him.

Sometimes lightning has been observed to enlighten the mind, and to give greater penetration to ideas, as if the intelligence were submitted to some stimulating or beneficial agency. Thus, the philosopher Ingenhous believed that he owed much to the discharge of a Leyden jar which he received on his head, though the commotion was so violent that he fell senseless to the ground, and remained for some instants deprived of reason, as if he had been struck by atmospheric lightning.

Who knows but what some propitious thunder pealed when Archimedes reflected upon the weight of Hiero's crown? when Newton imagined his law of gravitation? or when Arago perceived that the oscillations of a magnet became slower over a rotating disk of copper?

LVIII.

FRIGHTFUL EFFECTS OF LIGHTNING.

I CANNOT read without some emotion the simple narrative which the Abbé Richard gives, in his *Histoire de l'Air*, of the death of the attorney Simeon de Traci; for this truthful and naïve author, though rather too credulous, relates that the bones of the unfortunate man melted, and were instantaneously rotted by a

thunderbolt which fell somewhere in the neighbourhood.

How can I help adding, that a popular belief, mentioned by Peltier, before this fact was published, attributed effects like the above to thunder?

Can I pass over in silence the case mentioned by Dr. Mitié, of a woman struck by lightning in 1773, whose history appears to be authentic? When the body was picked up, they found that it was merely a gelatinous mass; the bones appeared to have been fluidified by some incredible chemical action, and to such an extent that there seemed to be none in her limbs.

In 1838, a violent storm burst over Nimeguen, and some bullocks were killed by lightning in the neighbouring fields. Their bones were found broken into a thousand pieces, as if the marrow enclosed in them had acted like fulminating powder.

Another similar fact was observed, according to Honorius, in the market-place of Pilnitz, in 1718. Eight sheep were killed by lightning; but when it was proposed to make use of their bodies as butcher's meat, it was found that such a number of fragments of bone had been dispersed through the tissues, that the meat was not fit to be eaten.

The electric explosion takes sometimes a more frightful form, if possible. The *Nautical Magazine* relates that a sailor was cut in two by a thunderbolt which struck the ship *African*, on the 1st of August, 1863.

On the 29th of April, 1769, four horses were found thrown down on the same side, upon a road near Romily in Picardy. Their intestines appeared to have been instantaneously expelled from their bodies.

In other cases, it is combustion which appears to act with frightful rapidity. Thus, a man mowing was killed I forget where, by lightning. Fire was seen in his hair;

his companions ran towards him, and his body was found to be literally covered with burns!

Strange and inexplicable cases are recorded, in which the electric fire appears to have concentrated itself so as to respect, or to leave intact, the skin of an animal, whilst its internal parts were reduced to ashes. Thus, Toaldo relates that the interior portions of the body of an ox were entirely consumed, whilst the skin remained as intact as the pheasant's feathers which decorate the dish on which the roasted bird reposes.

Le Laboureur tells us, in his *Histoire de Charles VI.*, that lightning, having penetrated through a small window in the apartment of the Dauphin, killed a young squire in the ante-chamber. The electric fluid appears to have consumed the whole of the inside of his body, leaving nothing but the skin, which was, however, as black as coal.

We read in an historical work, that the great Condé, coming to a cross road in the wood of Compiègne, saw a woman standing in the way of his carriage, who did not move aside in spite of his shouts. Becoming impatient at this obstinacy, he gave her a cut with his whip, when the figure immediately fell to dust. It was a mere heap of cinders, which held together by a kind of miracle. The woman had been struck by lightning a few minutes before.

When lightning struck the theatre at Feltre, in Venetia, six persons were burnt to ashes, according to the Abbé Richard, in his *Histoire de l' Air*, who deserves, perhaps, more confidence than the anonymous author of the above legend.

Antoine Louis declares, in his *Observations sur l' Electricité*, that lightning has been seen to crush a tree without impressing upon it the slightest sign of combustion, whilst it burnt to ashes a shepherd who happened to be sheltering under it. Whence comes this

difference of action? How is it that we find so much fire on one side, and so little on the other?

Must we consider all the cases related in this chapter as a series of hoaxes, even those related by serious authors? We have no hesitation in asserting that the Academy of Sciences would consider them as such.

LIX.

HOW DID THE BIRD GET OUT OF THE CAGE?

CERTAINLY, if we have a right to be terrified at the power of an agent which takes away the substance of our bones, we may fear still more its extraordinary subtilty. How can we prevent trembling when we see animals, and even men themselves, cease moving, thinking, living, suddenly, and without any appreciable change being operated in their appearance, or in the mechanism of their organization? "By what opening has the bird escaped?" to make use of the charming expression of Plutarch, who was acquainted with the phenomenon in question. How did it get out of its cage?

Dr. Peltier has collected a large number of examples which appear to be indisputable, unless we admit that the post-mortem examinations were carelessly made.

When M. Daussac was killed by lightning at Castres, he was on horseback, with two friends, as we said before, and the three horses were thrown down by the shock. In spite of the force of the explosion, it was impossible to find the slightest wound upon the bodies.

Four horses were struck by lightning some years later, in the neighbourhood of Dover. John Lyon, who relates the story, says that no mark told where they had been struck. On the 9th of September, 1843, several horses in a stable were killed by the electric fluid. They

showed, neither, not the slightest trace of any wound or scar, according to the report of the veterinary surgeons.

Perhaps those who profess the doctrine of *animal-machines* will see in these circumstances the proof that animals have no soul; in fact, the cage has no reason to open, as there is no soul to fly out: and as for men themselves, why they have often so very little.

Scheutzer asserts that no trace of a wound could be found on the body of a youth killed by lightning near Zurich.

Antoine Laires having had occasion to examine the body of a young man killed by the electric fluid at Metz, which he did with the greatest care, assures us that he could not discover the slightest mark of a burn or contusion.

The Abbé Richard relates that a labourer who was killed by lightning near to Aigueperse in the Bourbonnais, presented no bruise or wound of any kind upon his body. It would not have been possible to discover the cause of his death had not several persons seen the thunderbolt fall which struck him.

These examples, which we might multiply, appear too truthful to be called in doubt. But even should M. Antoine Laires, M. Scheutzer, and the Abbé Richard not have been able to extend their researches to man himself, we should nevertheless have felt disposed to resort to other explanations rather than apply the Cartesian idea of animal-machines.

Have we not seen enough to show that it is necessary to modify our vulgar notions of thunder and lightning? It is a most extravagant idea to compare the causes of thunder and the effects of lightning to the noise and effects of cannon and cannon-ball. We are face to face with an essentially superior force. It might be said that it constitutes a transition between this world and

a better one. In fact, it is really subject to transcendental laws, which our weak intelligence cannot grasp.

LX.

FRANKLIN AND FREDERICK THE GREAT.

It will perhaps not be useless to say a few words on the history of the discovery of lightning-conductors, a history which is very instructive in a century like the present, when it is customary to condemn without judgment all unfortunate dreamers possessed with a mania for hypotheses.[1]

Franklin was not led on by hazard, by imitation, or by reminiscences of what had been accomplished by the ancients. The discovery of the admirable instrument was for him the crowning of an edifice, the result of his experiments and observations on the nature of electricity.

Franklin did not see in the mysterious fluid a kind of

[1] If there is a fact more useful than another that should be impressed upon the mind of every young man who is about to enter upon a scientific career—a career of observation and thought—it is perhaps this, that the century we live in is eminently practical and utilitarian. What every one requires, what every one will listen to eagerly, are new facts; theories command little attention, hypothesis is rarely heeded. To accumulate new facts in science must be our aim, and, need we say it, facts accompanied by substantial proofs? Nothing more is necessary for the progress of science, for in course of time the facts will explain themselves. Nature, according to a distinguished philosopher, speaks to us in a peculiar language; the language of phenomena. She answers all the questions we ask her, and these questions are our experiments. Let us add, that when an experiment or an observation has furnished us with a new fact, we must be content for the present with what we have gained. Do not let us waste our time, and that of our fellow-creatures, by freaks of the imagination. Let us rather seek out another fact, which, in all probability, will amply account for the first. *[Translator's note.]*

material autonomy constantly realized. Nevertheless, however imperfect his ideas may have been, they raised him to immortality; for they caused him to launch an iron point into the clouds above.

The illustrious founder of the American Republic brought to bear in this experiment that truly positive tendency which characterizes the whole of his long and admirable career. He raised his iron point in the most simple, the most popular manner, by means of a common child's kite, such as might have amused schoolboys during their Easter holidays.

The frame of this rudimentary apparatus was formed of two cross sticks, which were covered by a silk handkerchief.

When thunder roared, the Cæsars of ancient Rome almost invariably shut themselves up in their subterraneous cavities. What a contrast we have in the former printer's mechanic, the descendant of the pilgrims of the *Mayflower*, choosing this very moment to incite the clouds! What protected his assistant, to whom was confided the task of raising the kite, and who was no other than his own son? The precaution taken to isolate the end of the string, by having a certain length of silk!

Questioned with such sublime boldness, the clouds were not long in sending their reply. The courageous and sagacious observer was not long in recognising with joy that he grasped the fire of the heavens contained in his simple apparatus. A spark was emitted whenever he approached his hand to the conducting portion of the string.

The principle of the lightning-conductor was thus discovered; but this magnificent experiment was not yet sufficient to realize it. How many others, how much thought, and what trouble were necessary to accomplish this! Nature herself is not always so difficult

to vanquish, but to tame her phenomena and make them profitable to man, the most terrible obstacle one meets is almost invariably man himself!

When the announcement of Franklin's discovery reached this side of the Atlantic, it was received with enthusiasm by some, and with outbursts of incredulity by others; which was natural enough. On the simple announcement of the project itself his experiment was realized in France by Dalibard before it was actually made in America.

The *Royal Society* of London received with superb scorn the account of these immortal experiments related in a communication by Dr. Mitchell. It required little more to stifle any further research. Vulgar caricatures were stuck up in the streets, and reverend gentlemen invited their lay brethren to forbid the use of so dangerous an instrument. A few centuries earlier, and Franklin would have been burnt alive, as many inventors of excellent things have been.

When the public mind was quieted by accumulated enlightenment, the torture was entirely of a moral nature. The most virulent opposition was that of a king, who gave himself the airs of a philosopher, and who liked to frequent their society.

Who would dare to affirm that the great Frederick was not infinitely humiliated when he learned that an unpretending naïve man, a species of clodhopper, had discovered a great secret, which had escaped all the physicists of his court, all the powdered, scented, frilled professors who sat in the *Royal Society* of Berlin?

What appears most evident is that he used as many endeavours to convince his people of the imposture of this American artisan, as he did to triumph over Maria Theresa. But he soon learned, at the expense of his *pride, that it was easier* to divide Poland, to snatch

Silesia from the daughter of the Cæsars, and even to gain the battle of Rosback, than to stop the progress of a scientific fact, of an invincible light!

A learned and amiable man, Dr. Fothergill, an influential member of the *Royal Society* of London, took under his protection the little treatise in which Franklin made known his discoveries. In a short time this immortal work was translated into Italian, into German, and even into Latin! His experiments were repeated by Romas at Nerac; at Montbard by Buffon himself; at St. Germain by Delor; at Turin by Beccaria, and, finally, in Russia by Professor Richmann. The latter, who had erected a cabinet at his own house that he might study the properties of lightning, perished by his zeal for science. A blue ball of fire emanating suddenly from the chain which he had attached to his lightning-conductor, struck him on the forehead and killed him instantly, in presence of the engraver Sokolow, who was also stunned and thrown to the ground.

Up to this time almost unknown in Europe, the philosopher of Philadelphia was now the object of universal attention. The different Academies sought eagerly to enroll him among their members. The Royal Society of London, to repair as much as possible the harm done, admitted him a fellow, and exempted him from the payment of the twenty-three guineas. But how many Franklins die before their contemporaries have time to recognise their errors! How many Franklins have not even the consolation of thinking that after their death their discoveries may come to light! Less fortunate than Kepler, for the most part, centuries must elapse before a single reader will be found worthy of understanding them.

The good-natured Franklin was not to be seduced by these honours; he remained, as before, unpretending, frank, and open; he accepted the Copley medal when

it was offered to him; he became an Associate of the Academy of Sciences, much as Leibnitz and Newton had consented to be called Doctors by the Universities of Edinburgh and Oxford.

Finally, a last triumph, the Academy of Berlin revolted against the dictations of their philosophical king. It recommended that lightning-conductors should be placed upon all the buildings of his Prussian Majesty. But the great Frederick revenged himself by forbidding that any should be affixed to his palace at Sans Souci.

Is it necessary to add that the immense popularity attached to the name of Franklin exercised a marvellous influence on the decision of the court at Versailles when the American insurgents demanded succour from France?

Who knows whether America would have been freed if Lord Cornwallis or Frederick the Great had discovered lightning-conductors, or if their inventor had allowed himself to be seduced by promises held forth by the great, with favours in perspective?

But if it had been so, would it authorize us to assert that it is small causes which produce great effects? Certainly not; nothing is small about a man who remains true to his country, to virtue, and an inflexible enemy to violence, oppression, and superstition in all its forms.

What is evidently very strange is the fact that Franklin was nearly deprived of his glory by a counsellor of the Presidial Court of Toulouse. The very moment that the learned American raised his kite towards the clouds, a Frenchman named De Romas was making the same experiment. He made his observations with a greater luxury of instruments, and drew from the string of his kite electric sparks which would certainly have killed him had he not withdrawn them by the aid of an instrument called an excitor, which permits us to mani-

pulate large charges of electricity without receiving the slightest shock. M. de Romas, it is true, possessed only a part of Franklin's genius, for he drew no practical conclusion from his marvellous experiment. But does not his name deserve to remain associated with that of his immortal competitor?

Perhaps we may be allowed to call attention to a singular circumstance which often presents itself in the history of science, and is none the less surprising on that account. How is it that these two men, living five thousand miles apart, who had never seen each other—who had, perhaps, never had the slightest communication one from the other,—how is it, we say, that they should have met together around the same idea, which for many thousands of years had never presented itself to the mind of any observer?

Must we, then, believe that there is a season for fertile conceptions, a period marked out for the ripening of the fruit of thought, as well as for the fruit of the earth; and that these great conceptions are born everywhere when this season arrives? In any case, what appears to us scarcely less strange, is to see that the use of electric kites has completely vanished, in spite of the important services they might render to meteorology, and of the numerous researches made at the present day in this department of science.

LXI.

A FEW WORDS ON THE HISTORY OF LIGHTNING-CONDUCTORS.

THE first experiments on lightning-conductors, published in the *Mémoires* of the Academy of Sciences,

bear the date of 1752; however, it was only in 1784 that the first conductor was fixed to a French building.

If this honour was reserved for the Louvre, it was owing to the numerous reclamations of the celebrated watchmaker Leroy, who was a member of the Academy; but in spite of his great perseverance, the third part of a century, as we see, was allowed to elapse before taking advantage of a discovery, the application of which had been recognised as indispensable. Strange contradiction of the human mind! It was the monarch fated to be struck down by the Revolution who gave this signal of progress in a country where the Academy itself hesitated. On the contrary, it was an Academy who imposed the use of lightning-conductors upon a king who flattered himself that he was a strong-minded man, and one of the princes of philosophy.

It was only in 1823, some thirty years after the introduction of this important innovation, that the French Academy prepared general instructions for the use of lightning-conductors: up to that time the engineers had been left to follow their own ideas, and they were not very much the worse off for that. It is worth while remarking that the said instructions were demanded by the authorities, and that it was not of its own accord that the Academy took up a subject for which it had always shown very little taste.

Was it an instinctive repugnance for a branch of science as yet unexplored, and in which the Cartesian idea (which the Academy imagined itself quit of for ever) bumps at every step against vulgar prejudice?

The tardy instructions of 1823 taught nothing to anybody. They contained nothing but commonplace scientific facts; however, they served to popularize the use of lightning-conductors, for they were circulated in profusion, not only in France, but also in foreign countries. They were useful to naval engineers in protect-

ing steamboats; to artillery officers for preserving powder-magazines. Finally, they were made use of by architects to protect large buildings and churches

However, many phenomena were observed, and we have indicated the most important of them in these pages, which proved that the system of protection indicated by the Academy was insufficient. It was then recognised that a lightning-conductor possessed the property of attracting lightning, so that it actually becomes a source of danger unless it acts in a perfectly satisfactory manner. Pressed by the increasing number of observations, the Academy resolved to revise the instructions of 1823, now recognised to be incomplete, and the whole of the physical section of the Institute was charged to report upon the subject.

The report, which appeared in 1854, formulated certain recommendations, which were vague enough. It advised that conductors should be kept in good order, that their extremities should be constantly kept in communication with pools of water. However, the report makes no indirect allusion even to the question of lateral discharges. It appears, also, that the phenomenon of the return stroke did not exist at all in the minds of the writers. Moreover, the means of carrying out their instructions at sea is in no way indicated. But it is there, more especially, that difficulty is experienced in uniting the different portions of the conductors, on account of the moveable nature of the higher portions of the masts. Sir William Snow Harris[1] furnished the fixed portions with metallic bands, on which

[1] The late Sir W. S. Harris, to whom we owe so many remarkable researches on electricity, published an exceedingly interesting paper in 1834, *On the Protection of Ships from Lightning*. Since the year 1842, almost all the ships of the Royal Navy have been furnished with his system of lightning-conductors, which has proved most efficacious. [Translator's note.]

slipped the moveable portions for a certain length, so that copper was always in contact with copper.

What appears most strange is that the Academical Commission should have absolutely ignored the existence of Harris's ingenious process, although the inventor was honoured with a recompense of the 1st Class in the Great Exhibition of 1851. In fact, the Report of the Commissioners makes no allusion to it whatever, and no one would have spoken about it had not Baron Charles Dupin, who appeared suddenly vexed at this omission, made certain observations upon it.

Some months later, the Minister of State requested the Academy of Sciences to give its advice as to the measures that should be adopted to protect the new part of the Louvre. These new buildings were planned to contain a great quantity of iron, sufficient indeed to justify the greatest anxiety in this respect.

This time the Commission did not forget to speak about the upward stroke. In fact, it recommended to the Minister, that the conductors should be put into communication with the metallic portions of the edifice, which formed the skeleton, as it were, of the building. If this advice had been followed, the Louvre would have been transported into an inhabited lightning-conductor! It would have prepared for the electric fluid a passage in every direction, and allowed it to give rise to an infinite number of discharges, such as we have already mentioned in this volume.

The smallest storm-cloud could not have shown itself above the horizon, without giving rise in this building to a multitude of currents circulating in every direction, producing headaches, convulsions, nervous affections of various kinds, &c.! But the architects, who were prudent on this occasion, trusted to chance and refused to *follow the* advice. Nevertheless, the beauti*ful and practical* researches of Sir W. S. Harris, which

establish in so clear a light the danger of lateral discharges, were the object of no report.[1]

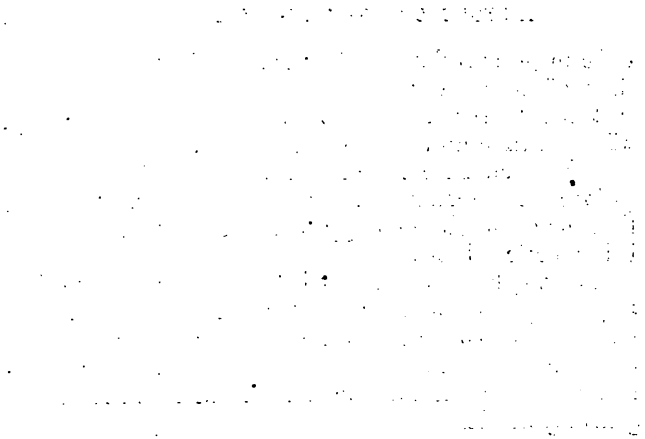
We have already indicated to our readers the principal incidents which appear to require a vigorous investigation, among others, the thunderbolt which fell on the powder-magazine at Bethune; the electric action of the body of a man struck by lightning in the streets of Paris; the rupture of gas-pipes, and the commencement of a conflagration thus produced in many quarters, &c.

By the rapid increase of electric telegraphs and new lines of railways, these electrical phenomena will not be much longer so completely neglected. The facts collected by a vast number of observers will group themselves naturally, and put in evidence many other remarkable phenomena. Minds of ingenious people will profit by these coincidences, and penetrate more deeply into the investigation of Nature. They will discover links hitherto unknown, which connect thunder and lightning with other natural phenomena. People will owe to them means of perfecting the instruments invented by Franklin, so that they may serve at least for studying the electrical state of the air, and give warning of the approach of storms. Very shortly, doubtless, there will not exist one lightning-conductor which will not have been transformed in some way or other into a forecasting instrument, not a single electric telegraph but what will be considered as a means of inquiry into the magnetic state of the earth.

Let us add that this electrical regeneration appears

[1] Of late years several interesting and instructive papers on lightning-conductors have been published by M. Melsens, the well-known professor of chemistry, in the *Bulletin* of the Royal Academy of Brussels (2d Series, tome xx. *et seq.*). One of their principal objects is the discovery of the best means of protecting the tower and building of the Hôtel de Ville of Brussels. [Translator's note.]

to be in preparation by the number of special publications of which lightning is the subject. Let us hope that the British Association, or some French society, will soon take up this subject, and that they may meet with the same success which has attended their investigations into so many other important phenomena; then the science of *Keraunology* will be established upon an indestructible basis.

May we have contributed to advance by one day only the period of so important a foundation, and we shall then be convinced of having rendered some service to Natural Science! For the theory of lightning certainly contains the solution of a considerable number of great mysteries.

THE END.